AAM for FAA/NASA Research Roundtable

February 19, 2020

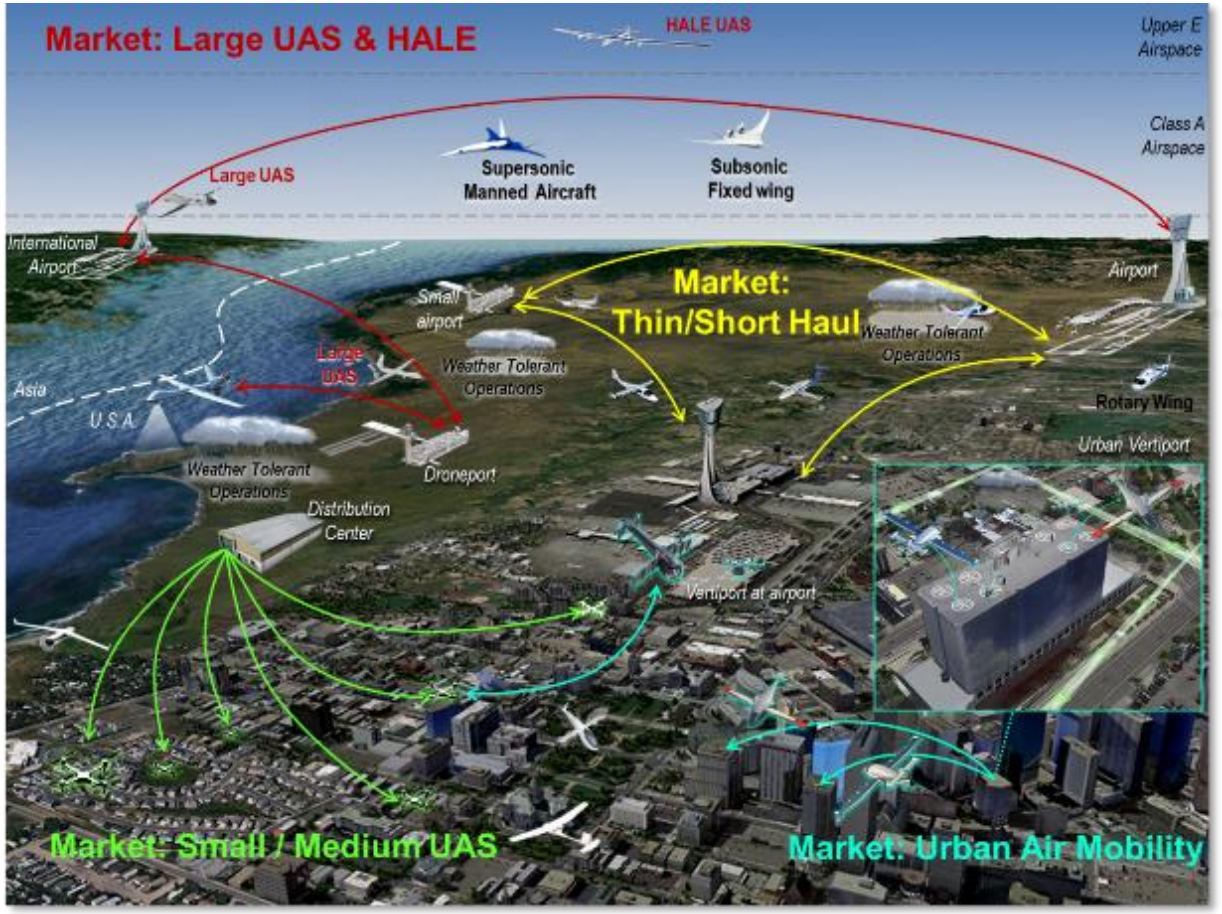
Advanced Air Mobility (AAM) Focus on UAM

- The AAM Project is responsible for working across ARMD to develop and implement an integrated plan for enabling Emerging Aviation Markets (EAM) that will provide substantial benefit to the US public and industry

- The AAM scope spans Emerging Aviation Markets (EAM)
  - s/mUAS,
  - Thin/Short Haul
  - Urban Air Mobility (UAM)
  - Large UAS & HALE

- UAM investments exceed several billion dollars, domestically and internationally, and US leadership is essential

- Focusing the AAM effort around the UAM challenges can provide significant benefit towards a broad set of EAM missions

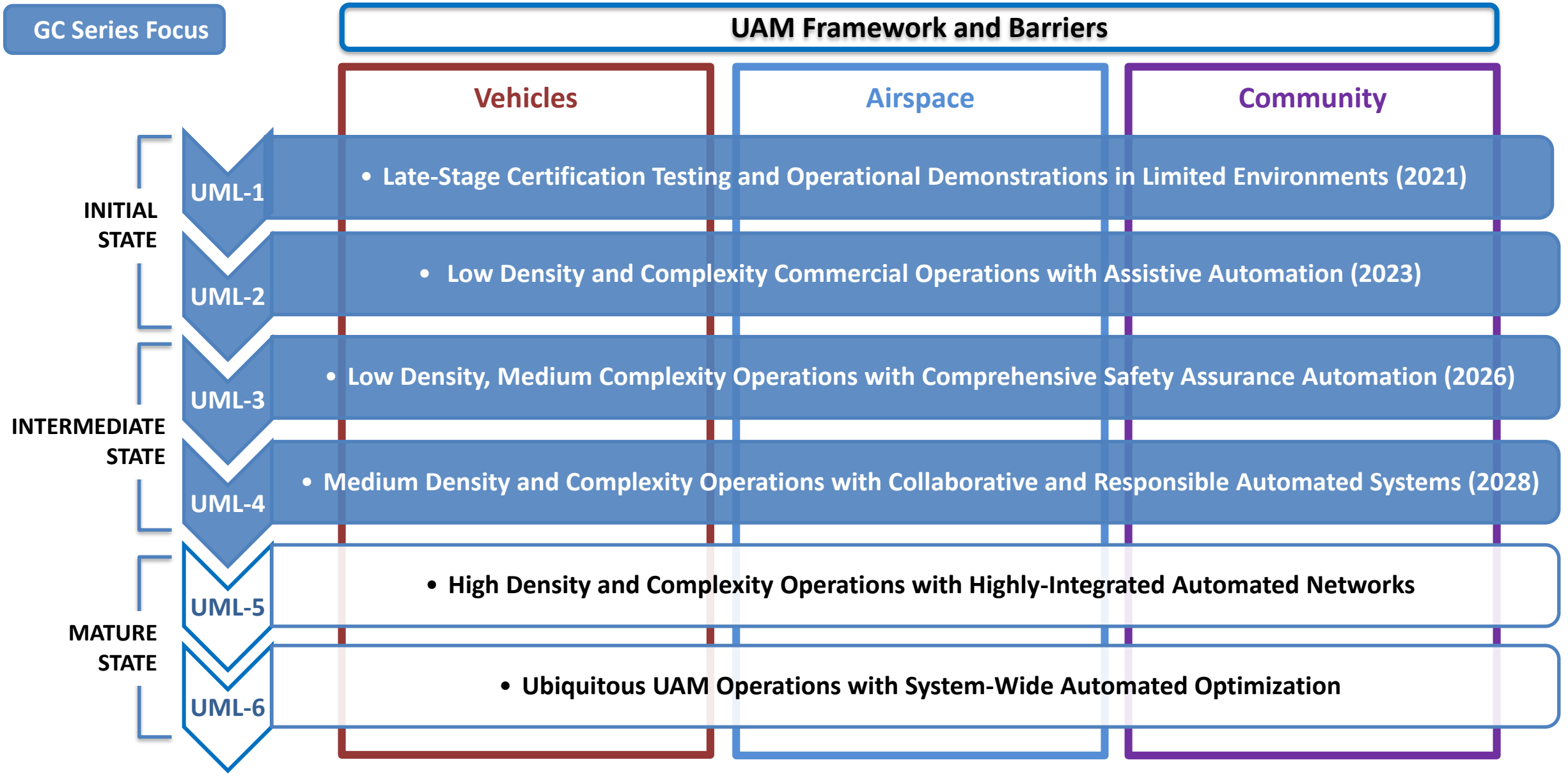


AAM is prioritizing UAM to advance Emerging Aviation Markets

UAM Maturity Levels (UML) with Representative Timeline*

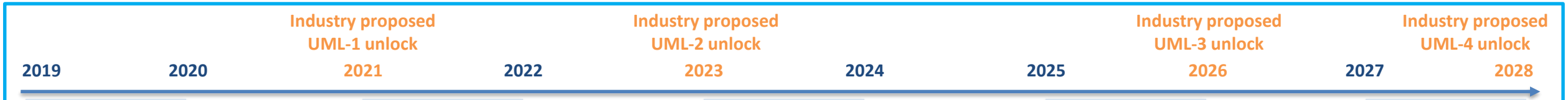
GC Series Focus

UAM Framework and Barriers



*Dates are representative of industry-proposed timeline; aggressive

ARMD Top UAM Priorities



1. *Catalyze the industry working to achieve UML-1&2*

- *Leverage Grand Challenge to enable near-term industry use cases*
- *Inform robust ConOps and system concepts in coordination with the FAA*
- *Support early adopter cities and ranges*

Remain flexible and agile. Anticipate changes in industry time lines and approaches as we learn!

2. *Develop a research portfolio that reduces risk of industry UML-3&4 timeline*

- *Development of advanced urban capable aircraft, analysis tools, technologies, metrics, and certification guidance*
- *Vehicle and airspace automation technologies to enable UML-4*
- *Integration and test of critical technologies and concepts*
- *Integration and operationalization of systems into the NAS*

DRAFT: AAM Project Organization

-- Draft Organization --
View of the unapproved automation subproject structure included

Integrated Aviation Systems Program (IASP)

UAM Mission Office

Advanced Air Mobility (AAM) Project Office

AAM Project Manager (PM): Davis Hackenberg
Deputy PM: Karen Cate
Deputy PM for Technology: Ken Goodrich
Associate PM: Ron Johnson
Chief Engineer: Colin Theodore
Lead Systems Engineer: Rich DeLoof

Assoc. PM for AFRC TBD	Assoc. PM for ARC TBD	Assoc. PM for GRC TBD	Assoc. PM for LaRC TBD

Administrative Office

Project PPC Lead: Nguyen Tran
Deputy PPC Lead: April Jungers
Business Administrator: Lexie Brown
Communications Lead: Jamie Turner
Scheduler: Irma Ruiz
Resource Analyst, AFRC: Glenda Almeida
Resource Analyst ARC: Christian Aguilar
Resource Analyst, GRC: Julie Blackett
Resource Analyst, LaRC: Tracey Frisby

Grand Challenge Subproject

GC Lead: Starr Ginn
Deputy for GC: Marcus Johnson
Integration Manager: TBD
Tech Leads

UAM Vehicle Automation

Subproject Manager: TBD
Tech Leads

Highly Automated sUAS

Subproject Manager: TBD
Tech Leads

The First UAM Grand Challenge

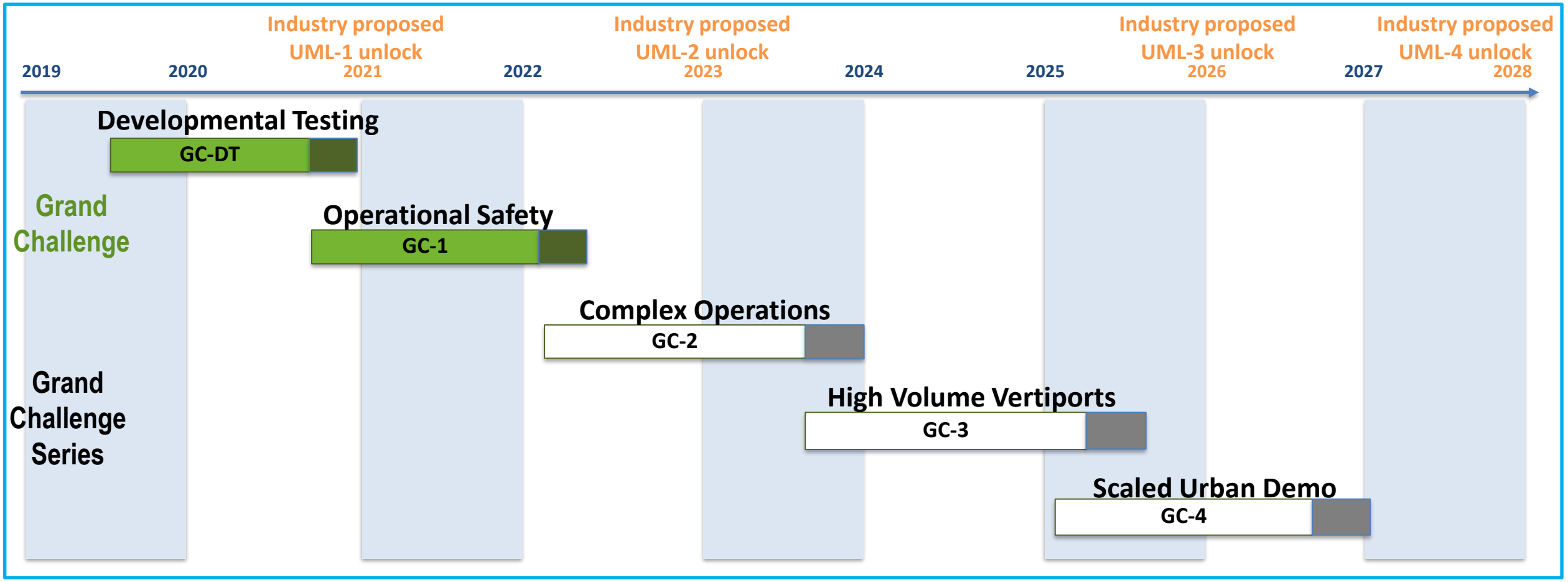
Goal Improve UAM safety and accelerate scalability through integrated demonstrations of candidate operational concepts and scenarios

Objectives

1. Accelerate Certification and Approval
2. Develop Flight Procedure Guidelines
3. Evaluate the CNS Trade-Space
4. Demonstrate an Airspace Operations Management (AOM) Architecture
5. Characterize Community Concerns

UAM GC Series Support of Industry Proposed Timeline

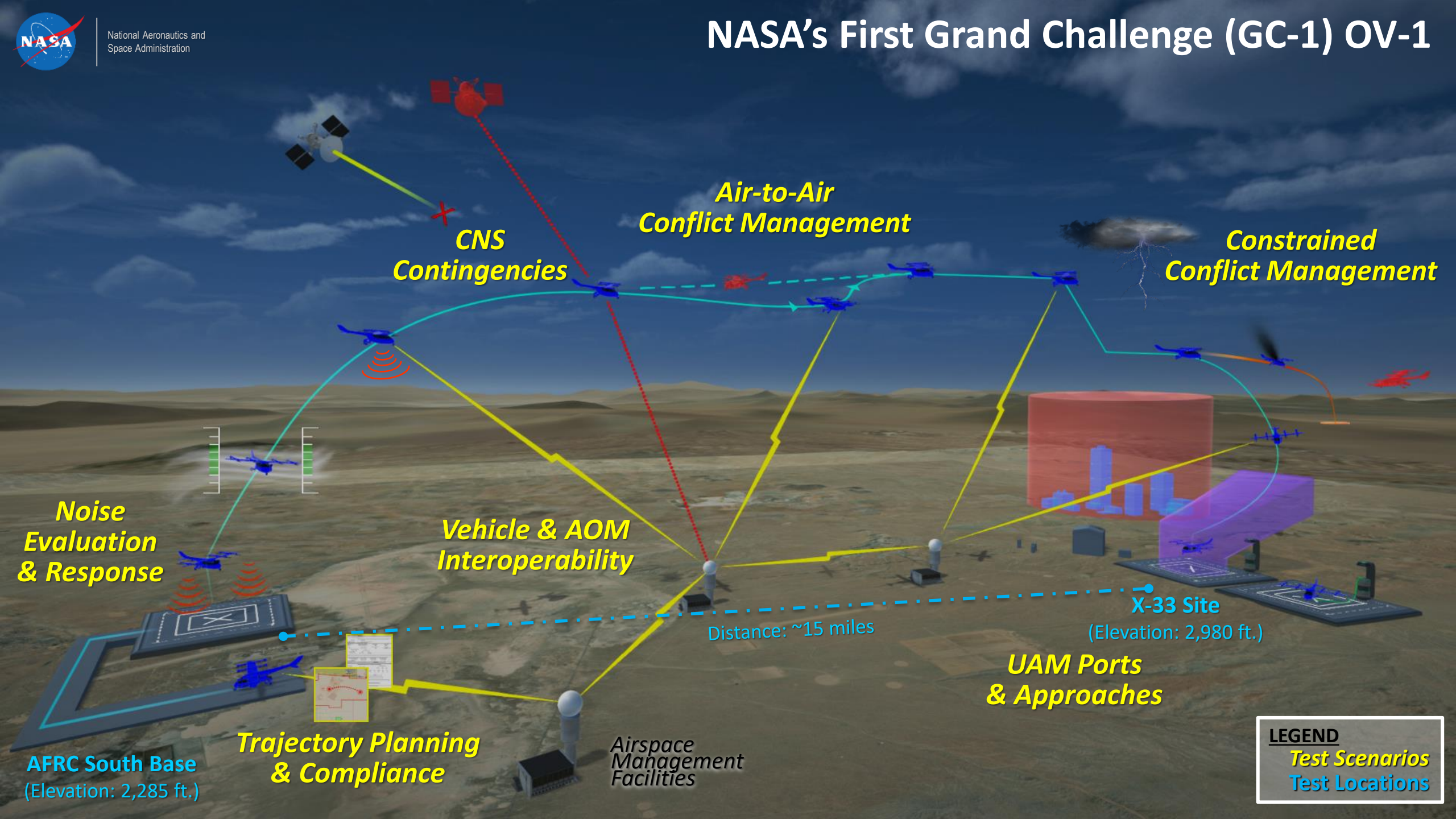
Based on a range of publicly available industry projections; not a consensus view; aggressive



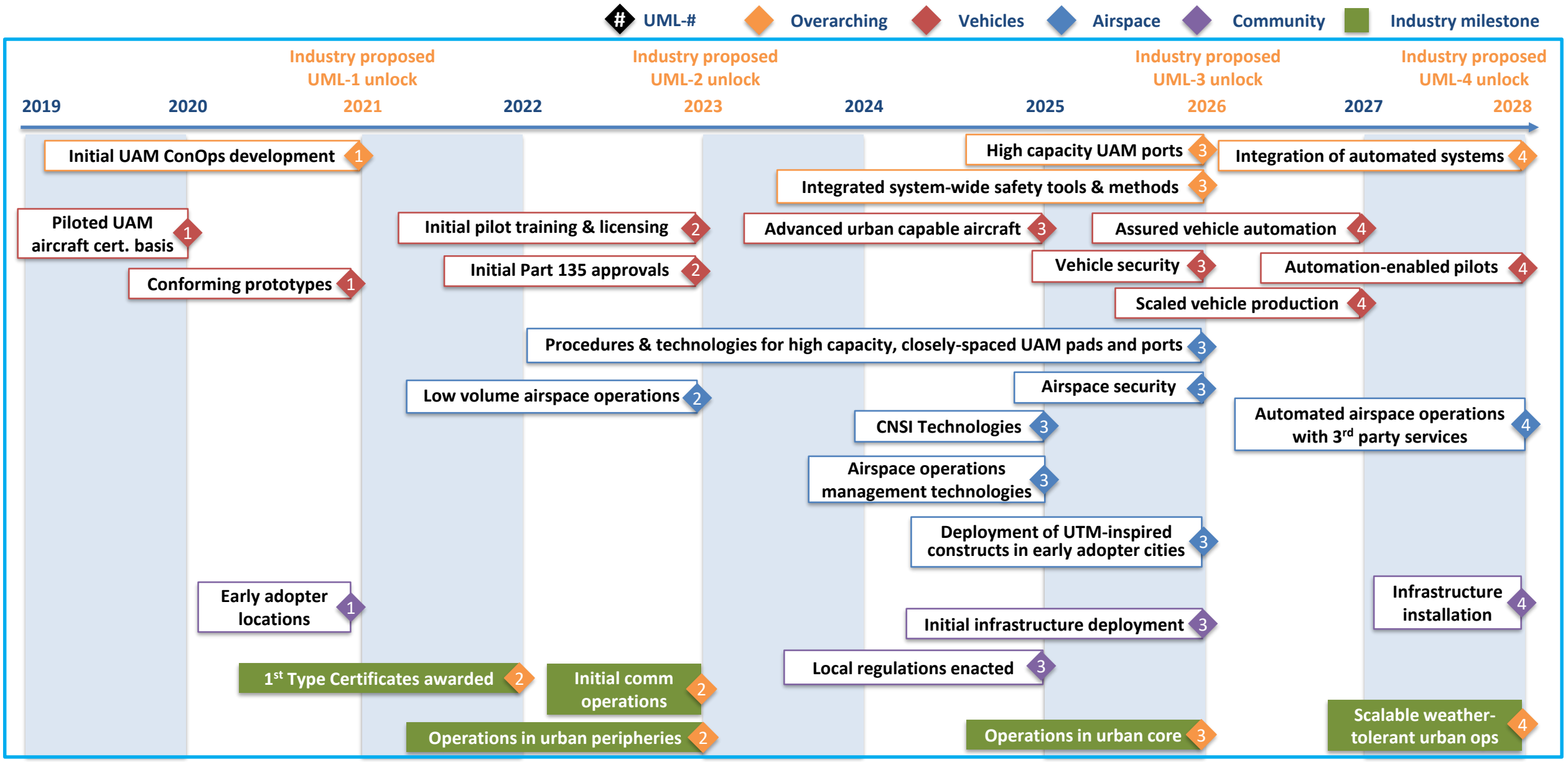
- Industry proposed timeline is aggressive and subject to delays; agility is essential
- GC-DT and GC-1 are designed to accelerate safe operational integration concepts for UAM
- GC Series progression defined, but intended to remain flexible/agile:
  - GC focused on achieving UML-4
  - Each GC can be an "off-ramp" to relevant UML unlocks, but GC progression is dependent on industry readiness and commitments

National Aeronautics and Space Administration

NASA's First Grand Challenge (GC-1) OV-1



Representative UAM Milestones and Industry Proposed Timeline[1]



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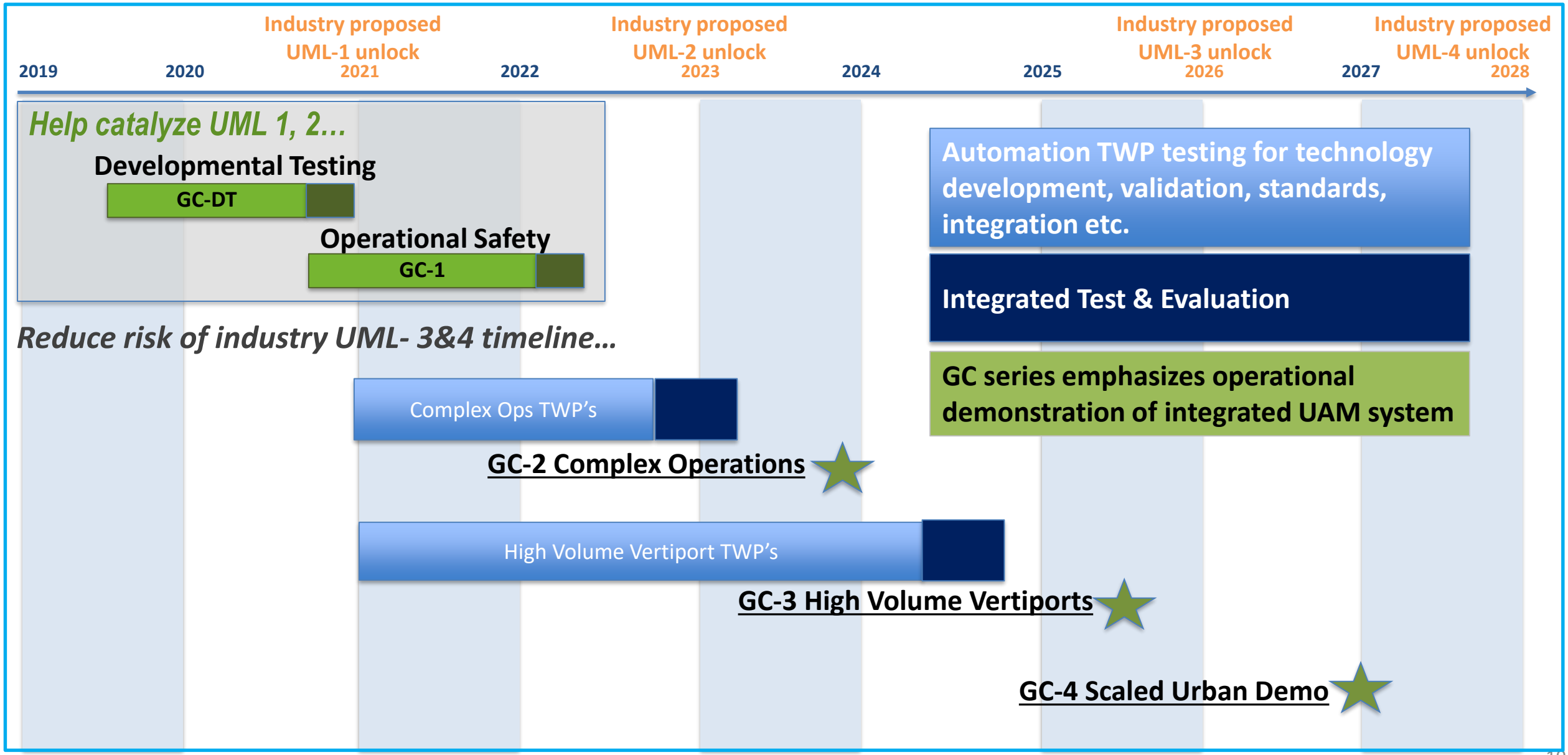
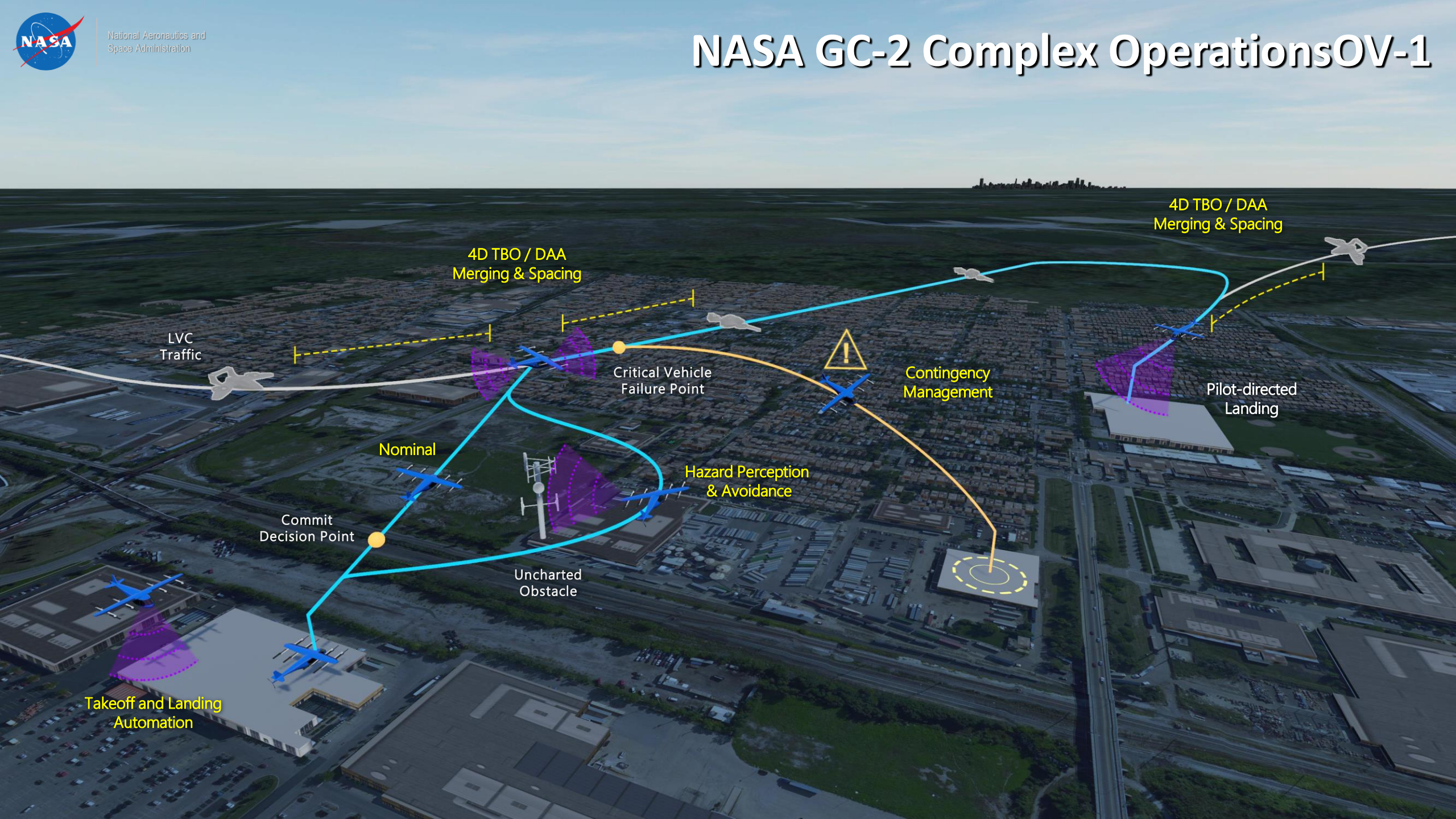
UAM Vehicle Automation Approach



National Aeronautics and Space Administration

NASA GC-2 Complex OperationsOV-1



AAM Automation Scope

Focus Areas	Scope	Community progress: Emerging progress → Mature progress
Integration of Automated Systems	▪ Integrated system concepts and supporting requirements & standards for highly-automated vehicle, airspace, and infrastructure systems. ▪ Vehicle/human-automation teaming patterned on vehicle holding role/responsibility of first-officer/pilot flying while human pilot (on- or off-board) has high-level command authority	
Automation-Enabled Pilots	▪ Guidelines and standards for revising and validating pilot/operator functions, certification and experience requirements (e.g. Parts 61, 91, 135) based on changes to roles, responsibilities, and authorities due to appropriately designed, highly-automated aircraft	
Assured vehicle Automation	▪ Flight-system concepts and technologies enabling effective, fault-tolerant, certifiable, automated functions (e.g. perception, autoland, contingency management, etc) to help pilots	
Integrated Security	▪ Integration of security considerations and requirements into overall system architecture with an emphasis within AAM on physical and cybersecurity of the vehicle segment and operations	
Scalable CNSI	▪ Trade-studies, requirements, and technology options for CNSi considerations necessary for highly-automated UAM systems and operations	

Urban Air Mobility Mission Office Overview for the FAA-NASA Research Roundtable

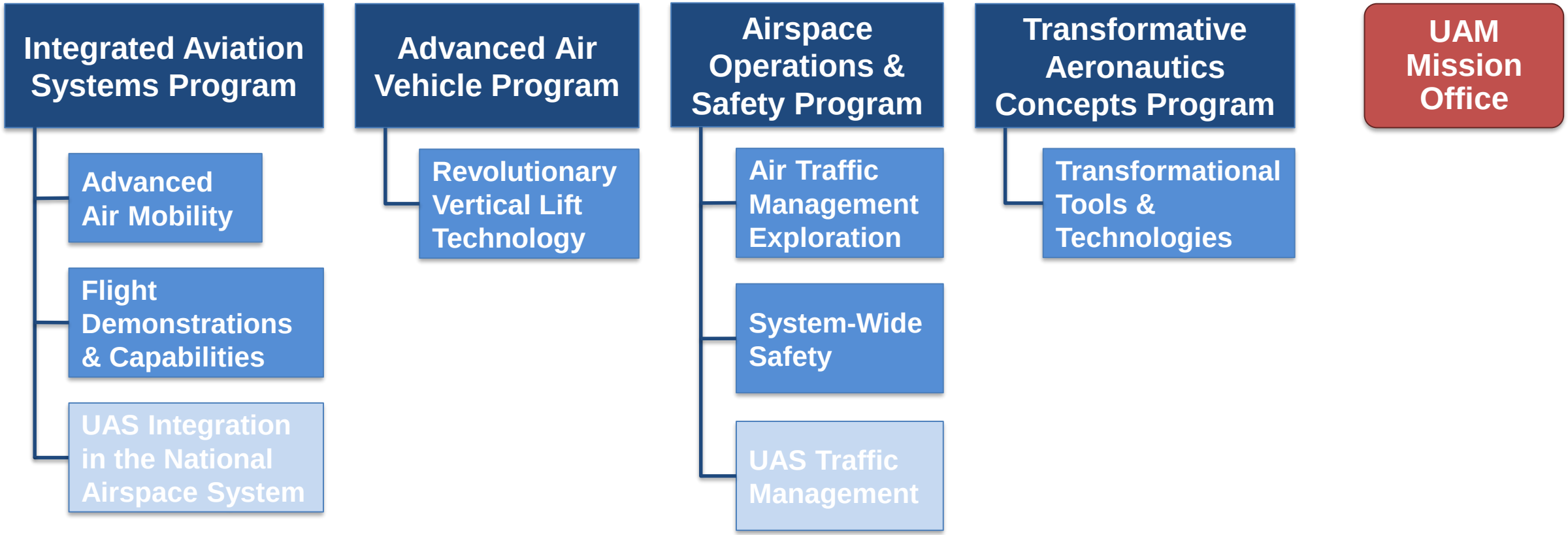
February 19, 2020

Background: Urban Air Mobility (UAM) at NASA

- UAM work within NASA's Aeronautics Research Mission Directorate (ARMD) is growing out of multiple, parallel paths: largely on-demand mobility, UAS (of all kinds), & rotorcraft research
  - Significant past/ongoing efforts include Green Flight Challenge, UAS Integration into the NAS, Zip Aviation Study, Greased Lightning (GL-10), UAS Traffic Management (UTM), X-57, ODM Roadmapping Workshops, RVLT
- UAM Coordination & Assessment Team (UCAT)
  - Formed in early 2018; sunset end of FY19
  - Provided recommendations for an ARMD approach to enable the emergence and growth of safe, practical, and accessible UAM systems
  - Performed initial planning and formulation of the UAM Grand Challenge (GC)
  - Sponsored multiple system and feasibility studies†
- New UAM Mission Office (UMO) is planning to
  - Monitor and recommend investments supporting UAM to ARMD
  - Coordinate research and outreach activities across ARMD
  - Steward development of a common UAM System Architecture, including a ConOps and "Book of Requirements and Guidelines"

†Public links to results of many of these studies are located in backup slides

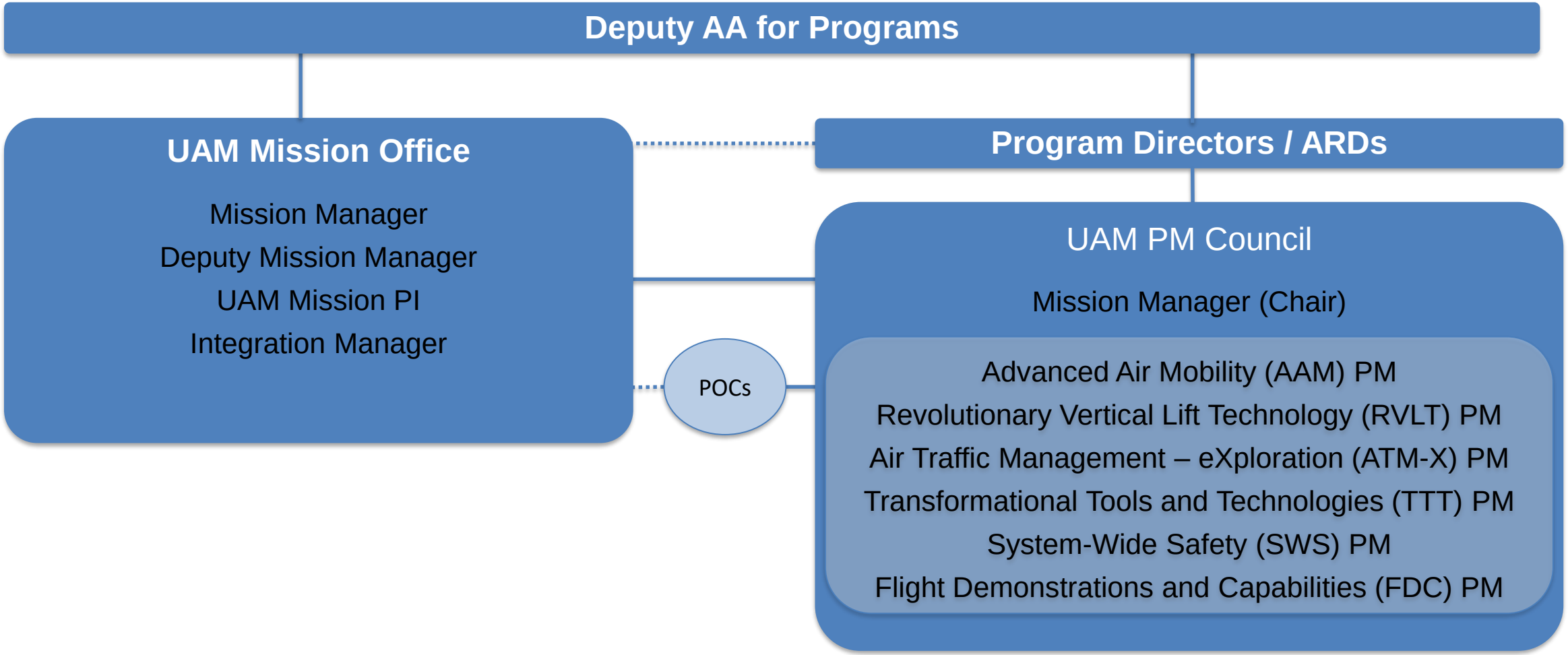
ARMD Organization with UAM-Related Projects



ARMD to develop a "UAM Mission Plan" that enables synchronization of all projects' UAM-related efforts

Program Project Concluding Project Cross-Program/Project

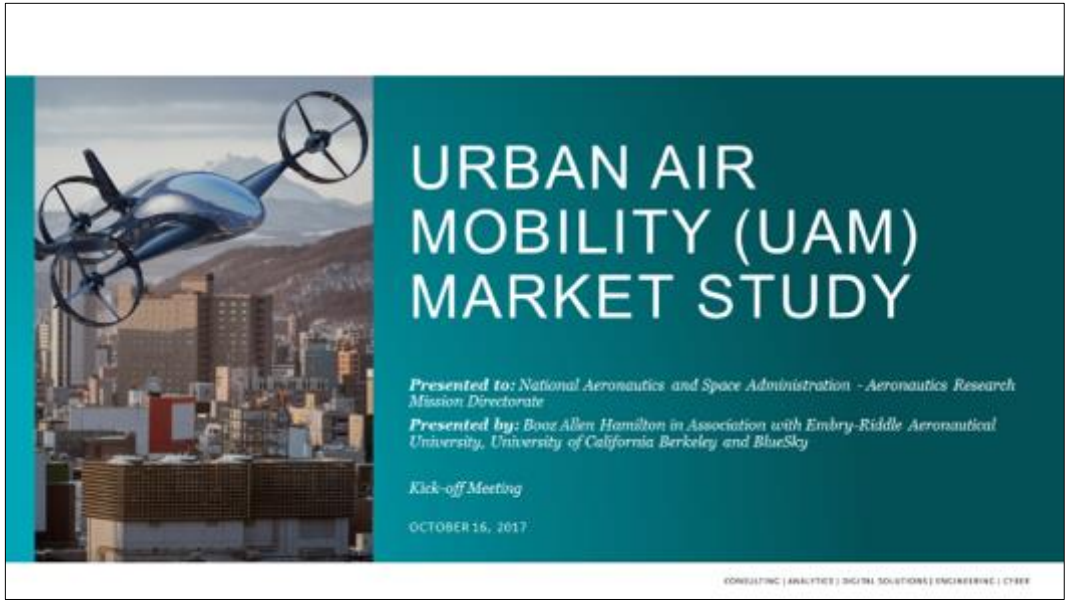
UAM Mission Office (UMO)



Urban Air Mobility Market Studies

- ARMD funded two UAM market studies that included
  - Several air taxi/metro models, air ambulance, and last-mile package delivery
  - Considerations for different urban areas, legal and regulatory barriers, & social acceptance issues
- UAM market studies generally found that UAM has economically viable use cases if many challenges are overcome
- Large variability in specific predictions across studies based on differences in assumptions
- Overview of Results:
  - Some assumptions show by ~2028 a highly-automated "air metro" could be profitable and by ~2030 result in ~750M annual passenger trips in 15 metro areas or ~137k pax trips/day/area
  - More conservative assumptions indicate a $2.5B passenger transport market with ~8.2k pax trips/day/area
  - Air ambulance model may not be profitable, but have high impact on public good
  - By ~2030 "last mile package delivery" could be profitable and result in ~500M deliveries annually

Reports posted at https://www.nasa.gov/uam-studies-reports/

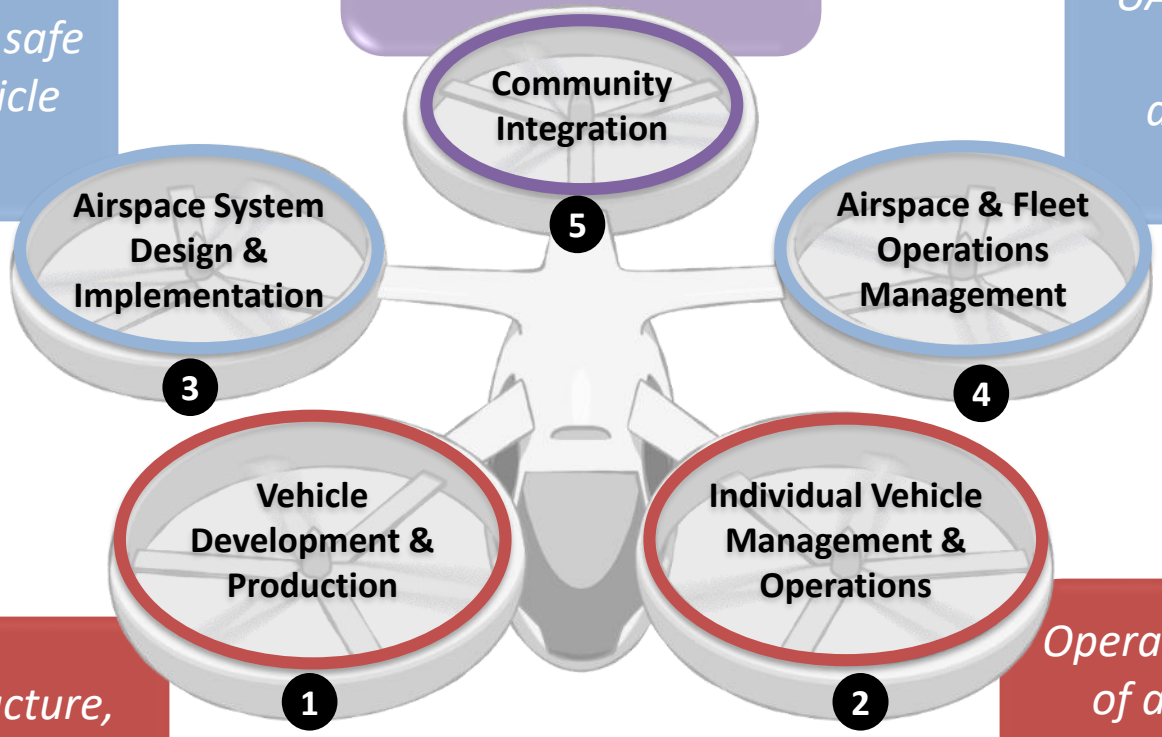


UAM Vision and Framework

Societal integration and acceptance of UAM operations

Design, development, and implementation of infrastructure to enable safe and efficient multi-vehicle UAM operations

Operations and management of multiple vehicles within a UAM system that enable safe and efficient sharing of airspace and other system resources



Design, manufacture, and system readiness of UAM vehicles

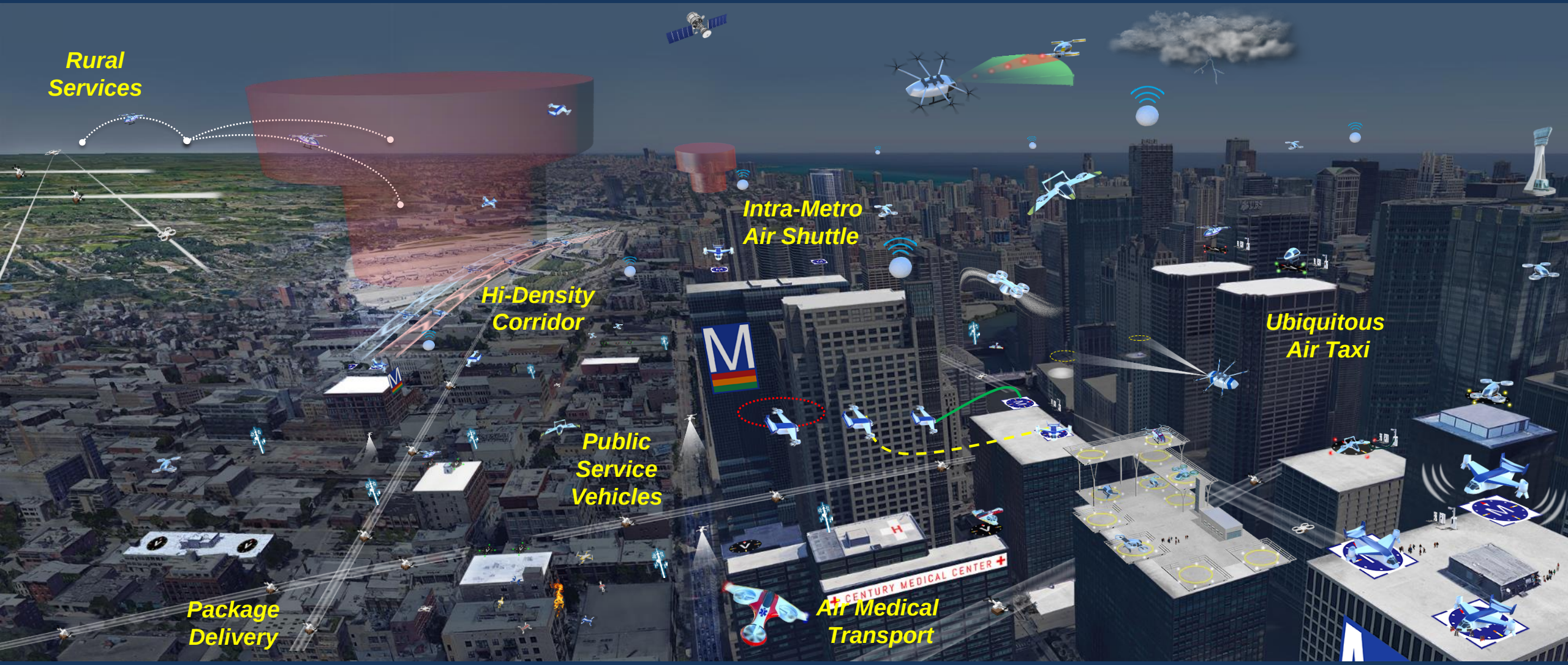
Operations and maintenance of a single UAM vehicle, independent of the sharing of airspace or other system resources

Urban Air Mobility (UAM) Vision
Revolutionize mobility around metropolitan areas by enabling a safe, efficient, convenient, affordable, and accessible air transportation system for passengers and cargo

Aircraft & Aircrew
Airspace
Community Integration
 # Pillar number

ARMD UAM Goal

Develop a validated UAM System Architecture that defines a safe and certifiable scaled UAM system



Final GC: Scaled urban demonstrations designed to validate the UAM system concept and corresponding set of requirements

UAM Maturity Levels (UML) with Representative Timeline*

GC Series Focus

UAM Framework and Barriers

	Vehicles	Airspace	Community
INITIAL STATE — UML-1	• Late-Stage Certification Testing and Operational Demonstrations in Limited Environments (2021)		
INITIAL STATE — UML-2	• Low Density and Complexity Commercial Operations with Assistive Automation (2023)		
INTERMEDIATE STATE — UML-3	• Low Density, Medium Complexity Operations with Comprehensive Safety Assurance Automation (2026)		
INTERMEDIATE STATE — UML-4	• Medium Density and Complexity Operations with Collaborative and Responsible Automated Systems (2028)		
MATURE STATE — UML-5	• High Density and Complexity Operations with Highly-Integrated Automated Networks		
MATURE STATE — UML-6	• Ubiquitous UAM Operations with System-Wide Automated Optimization		

*Dates are representative of industry-proposed timeline; aggressive

ARMD UAM Goal

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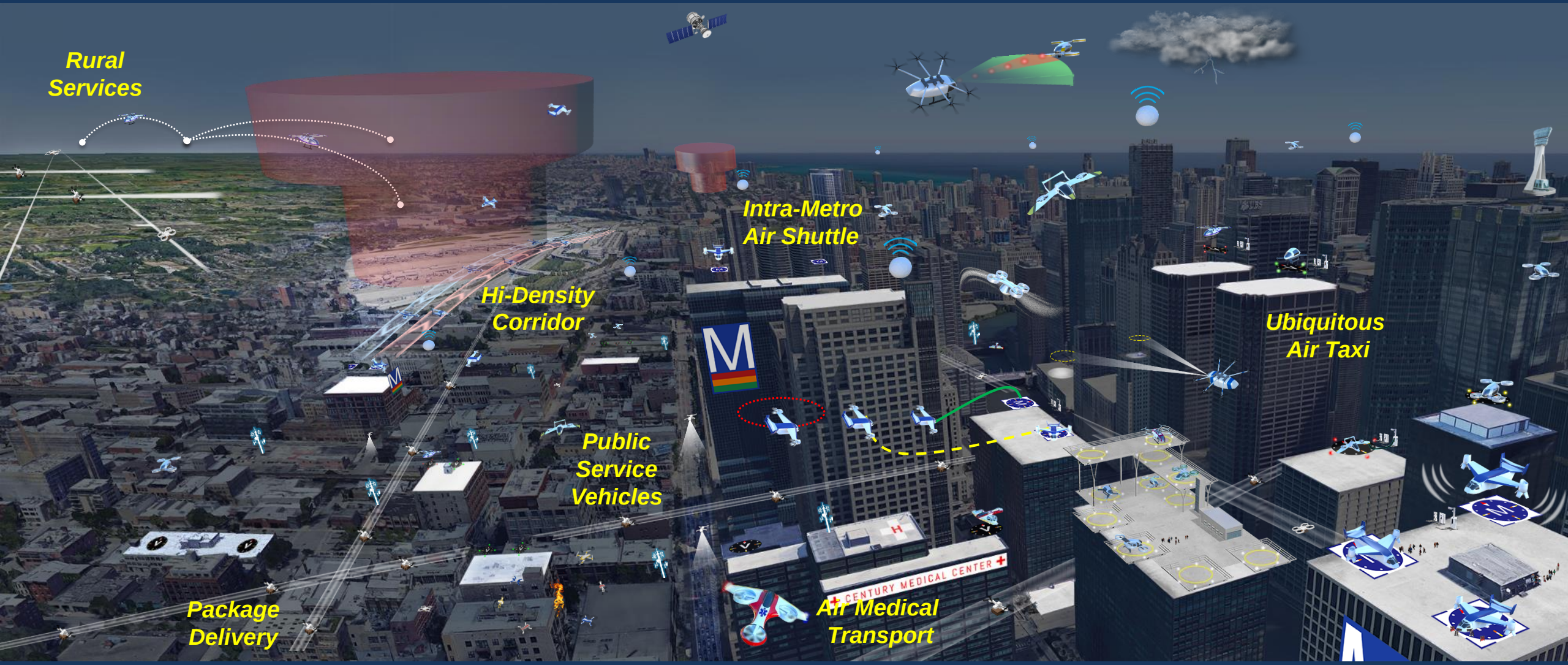

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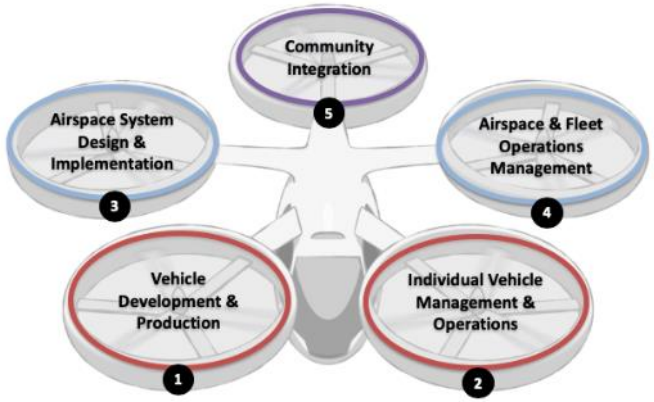
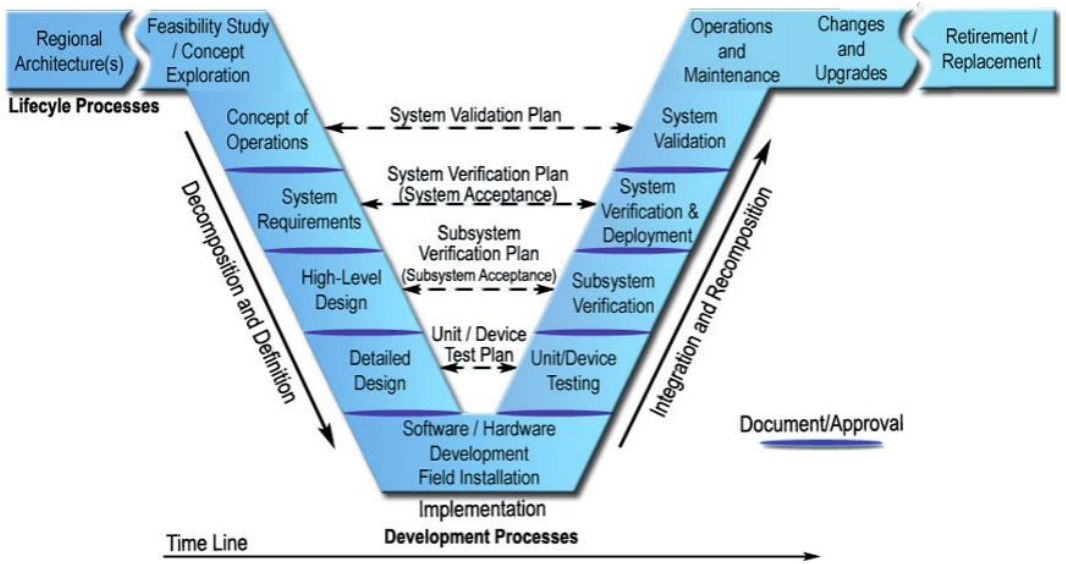
UAM System Architecture





[https://ops.fhwa.dot.gov/publications/seitsguide/seguide.pdf]

"System Concept"

- Explore viable system concepts include target levels of safety, interoperability, user attributes, community integration, etc.
- Trade-space exploration across ConOps, system concepts, technologies, etc.
- Assess feasibility, scalability, cost, regulation, etc.
- Develop critical technology prototypes (e.g., UTM-construct, simplified piloting)

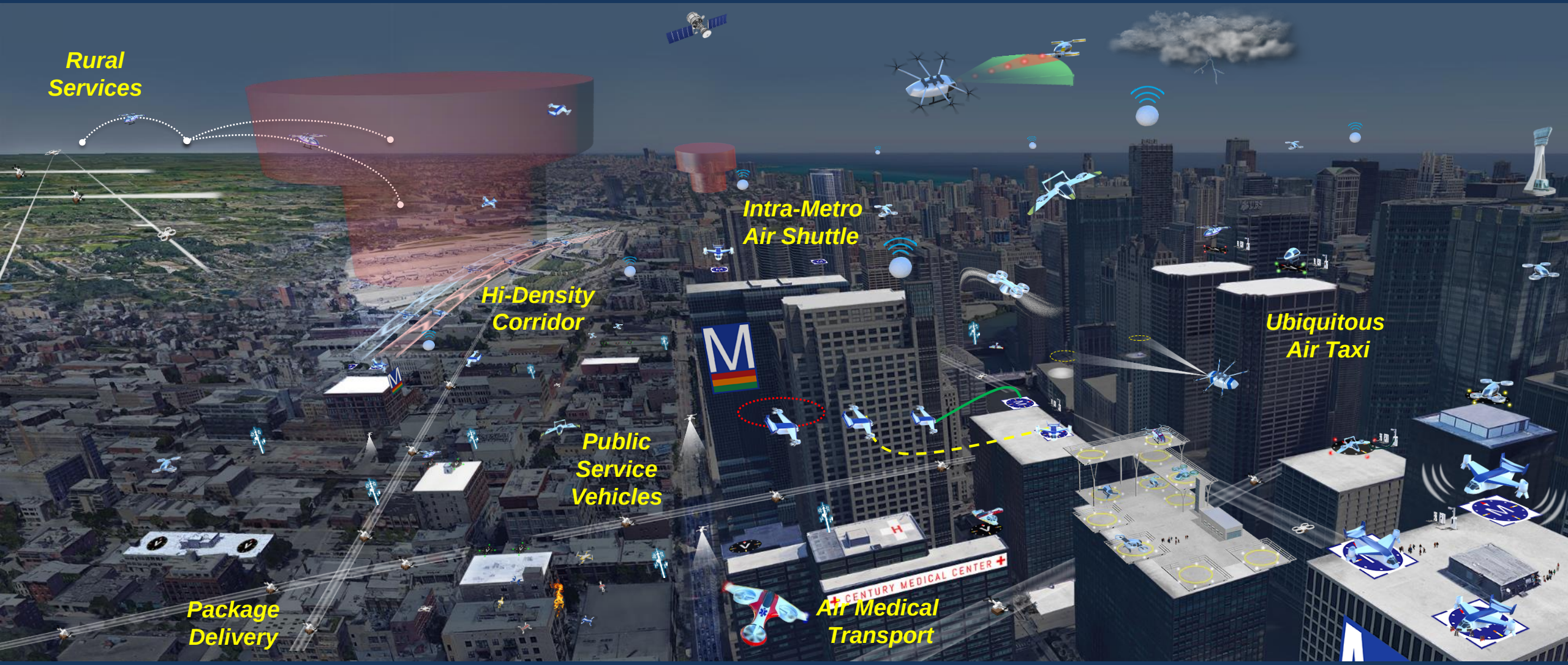
"Book of Requirements and Guidelines" (BoRG)

- Validated system concept and architecture
- "Requirements" and Guidelines developed in concert with FAA and industry standards bodies
- Spans all 5 pillars
- May include standards, regulatory guidance, recommended practices, acceptance metrics, or etc.
- Foundation of detailed design for operationally deployed system

UAM System Architecture will catalyze the UAM Industry

ARMD UAM Goal

Develop a validated UAM System Architecture that defines a safe and certifiable scaled UAM system



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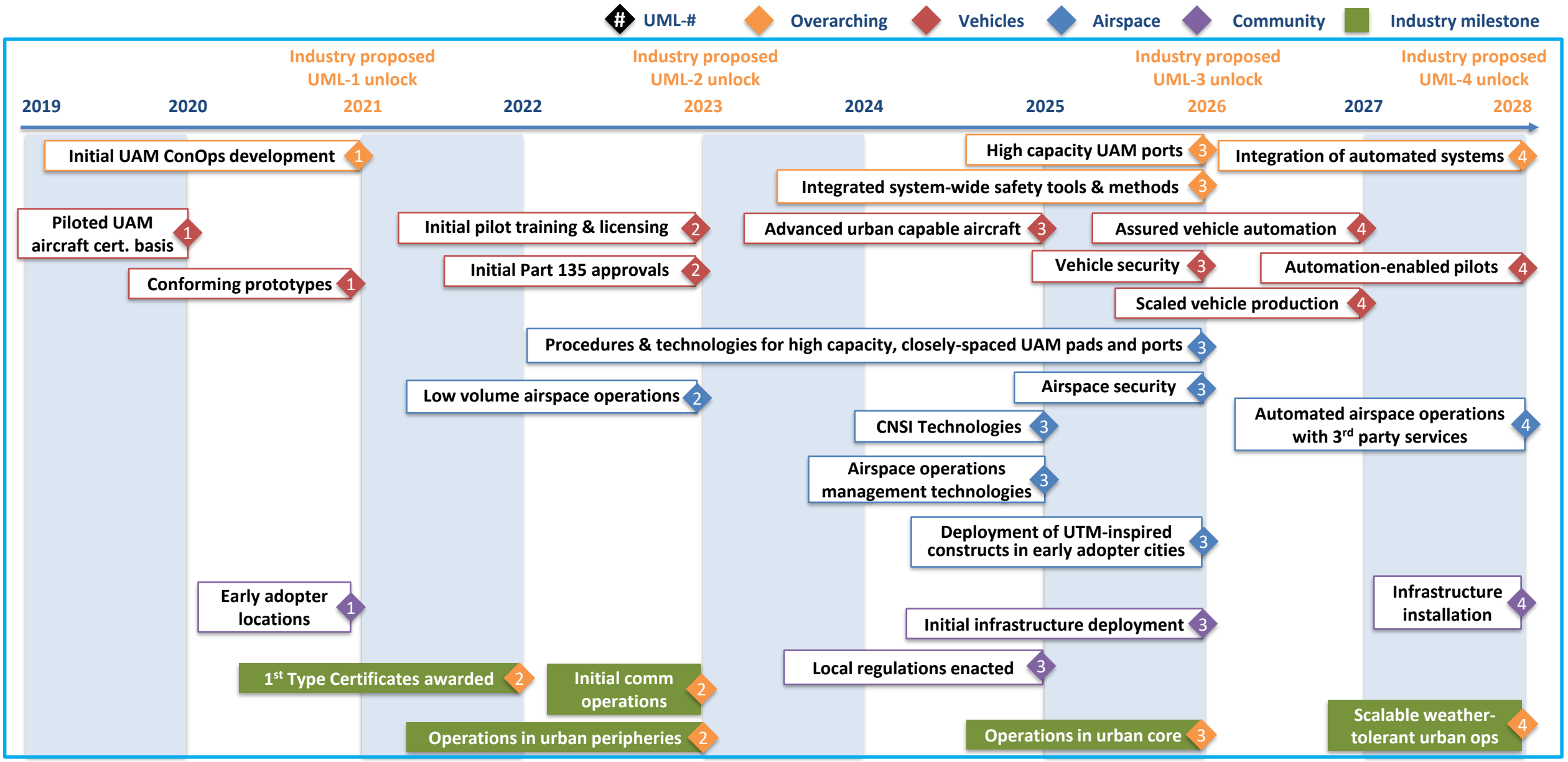

[1]Based on a range of publicly available industry projections; not a consensus view; aggressive

NASA UAM Ecosystem Partnership Approach

NASA intends to establish partnerships with government, industry and academia to collaborate on the critical enabling technologies and vital research relevant to UAM.

Project Research Partnerships

NASA/FAA Executive Board

Vehicle Partners

Airspace Partners

Academia

Grand Challenge Series

The enabler that informs the UAM Ecosystem

Scaled Urban Demo

UAM Community Integration Partnerships

Professional Associations and Standards

Other Gov't Agencies

State / Local

International

Community Outcome

"Validated" UML-4 System Architecture

NASA must have a focused ecosystem-wide partnership strategy to enable UML-4

NASA plans to partner with Federal/State/Local authorities as well as international & professional associations to develop the policies, regulations and standards necessary to enable the UAM market.

ARMD Top UAM Priorities

2019	2020	Industry proposed UML-1 unlock[1] 2021	2022	Industry proposed UML-2 unlock[1] 2023	2024	2025	Industry proposed UML-3 unlock[1] 2026	2027	Industry proposed UML-4 unlock[1] 2028

1. *Catalyze the industry working to achieve UML-1&2*

- *Leverage Grand Challenge to enable near-term industry use cases*
- *Inform robust ConOps and system concepts in coordination with the FAA*
- *Support early adopter cities and ranges*

Remain flexible and agile. Anticipate changes in industry time lines and approaches as we learn!

2. *Develop a research portfolio that reduces risk of industry UML-3&4 timeline*

- *Development of advanced urban capable aircraft concepts, analysis tools, technologies, metrics, and certification guidance*
- *Vehicle and airspace automation technologies to enable UML-4*
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UAM Contributions and Outcomes

NASA Contributions

ARMD Research

- Advanced Air Mobility (AAM)
- Air Traffic Management – eXploration (ATM-X)
- Flight Demos and Capabilities (FDC)
- Revolutionary Vertical Lift Technology (RVLT)
- System Wide Safety (SWS)
- Transformational Tools & Technologies (TTT)

UAM Mission Office

Integration and Alignment

- ***UAM Mission Strategy***
- **UML-4 System Architecture**
  - UAM System Concepts, Architectures, & Use Cases
  - UAM Requirements
  - UAM Guidance Material
  - UAM Scorecard
  - Model Based Systems Engineering
- ***Ecosystem Partnership Strategy***
- ***Outreach Strategy***

Grand Challenge Findings & Recommendations

- ***Technology Maturation***
- ***Automation Advancements***
- ***Best Practices & Lessons Learned***
- ***Modeling, Simulation, & Analysis Findings***
- ***Test & Evaluation Data***

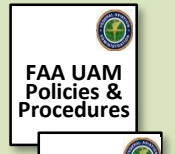
Community Outcomes

Validated ConOps & Business Cases

UAM Standards

Technical Standard Orders

Airworthiness & Production Certification



Policies & Procedures

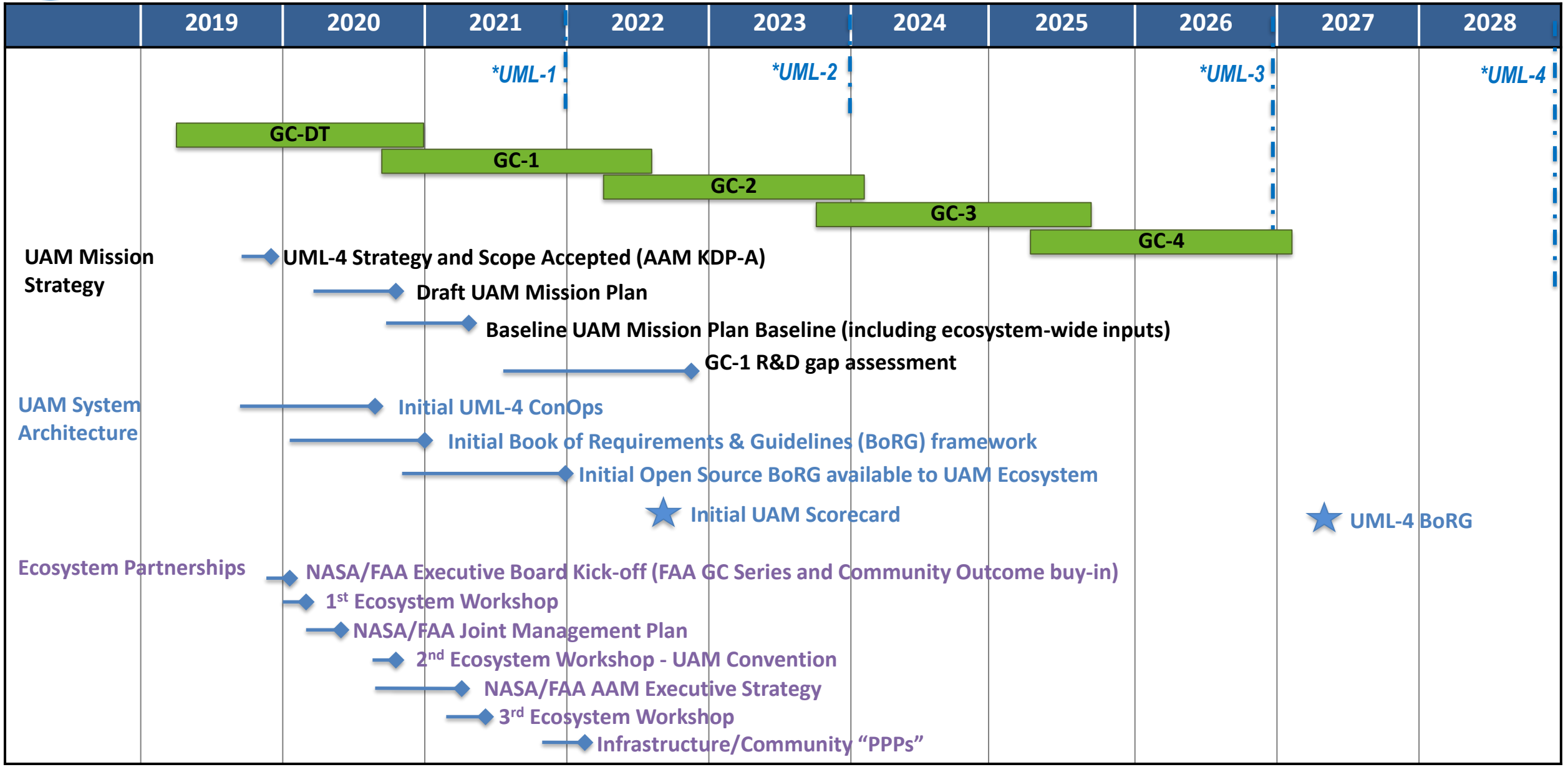
Rules & Regulations

State / Local Laws & Ordinances

Community Contributions

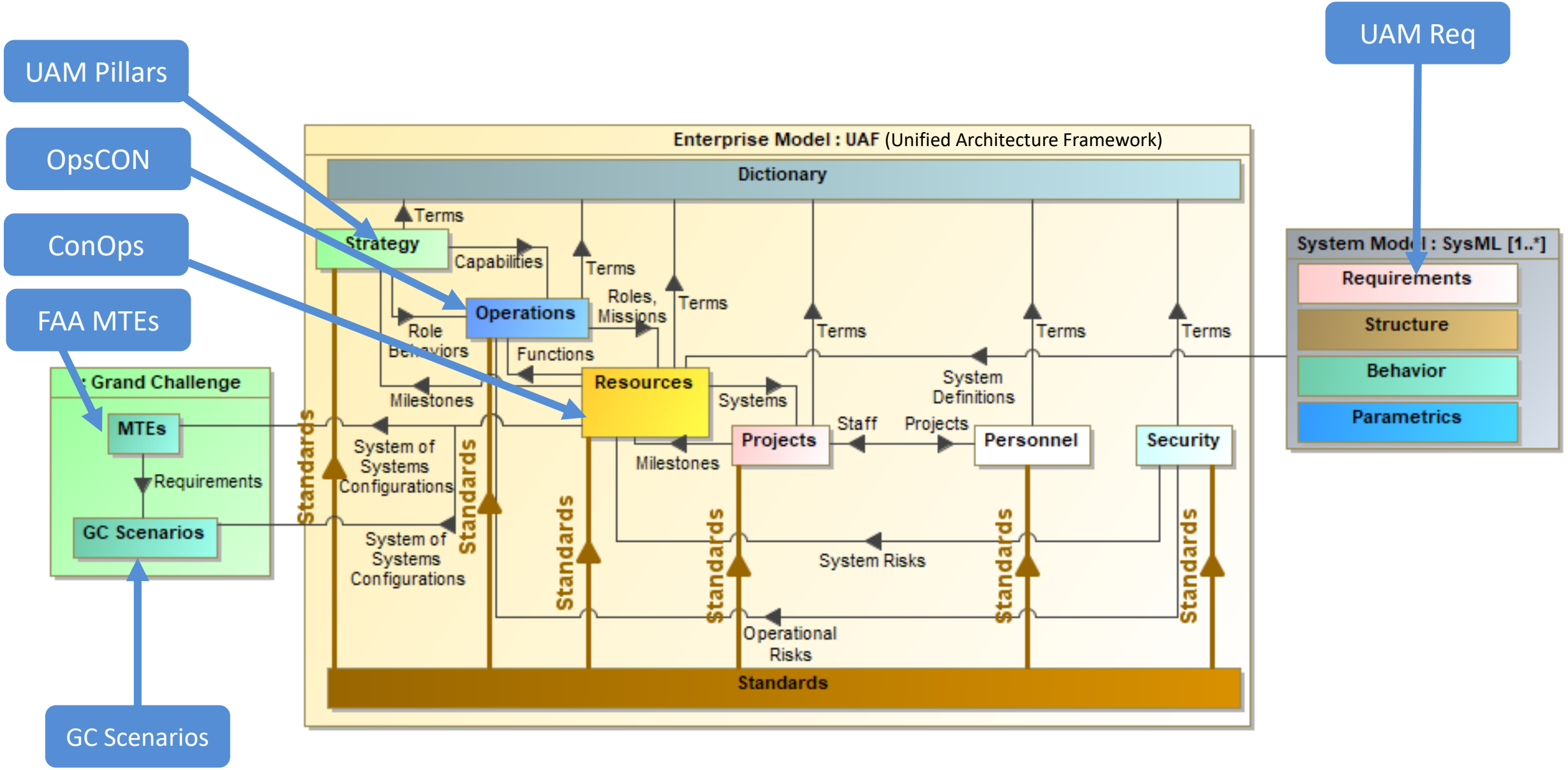
- ***Strategic Partnerships***
- ***Previous & Ongoing Research***
- ***Industry Innovation & Investment***

UAM Mission Overview



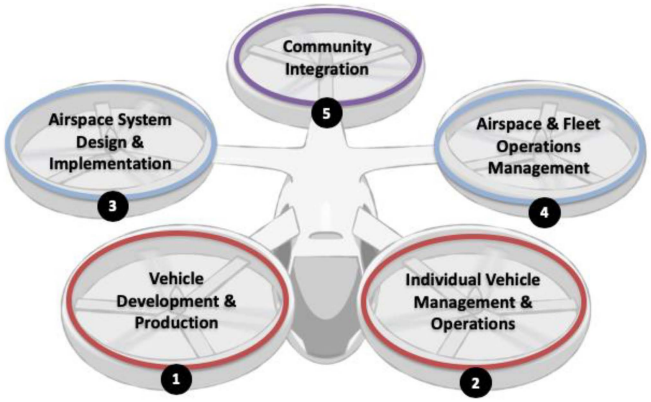
*Approximate, industry-proposed date for realizing capability

Example MBSE Model for the UAM System Architecture



The following 3 slides dive down to lower levels of this example UAM System Architecture

Example MBSE Model: Vision and Framework (Enterprise Goals)



Strategic Structure [Top-Layer of Pillars]

«VisionStatement»
Revolutionize mobility around metropolitan areas by enabling a safe, efficient, convenient, affordable, and accessible air transportation system for passengers and cargo.

«EnterpriseVision»
UAM Vision

«trace»

«EnterpriseGoal»
Vehicle Development & Production

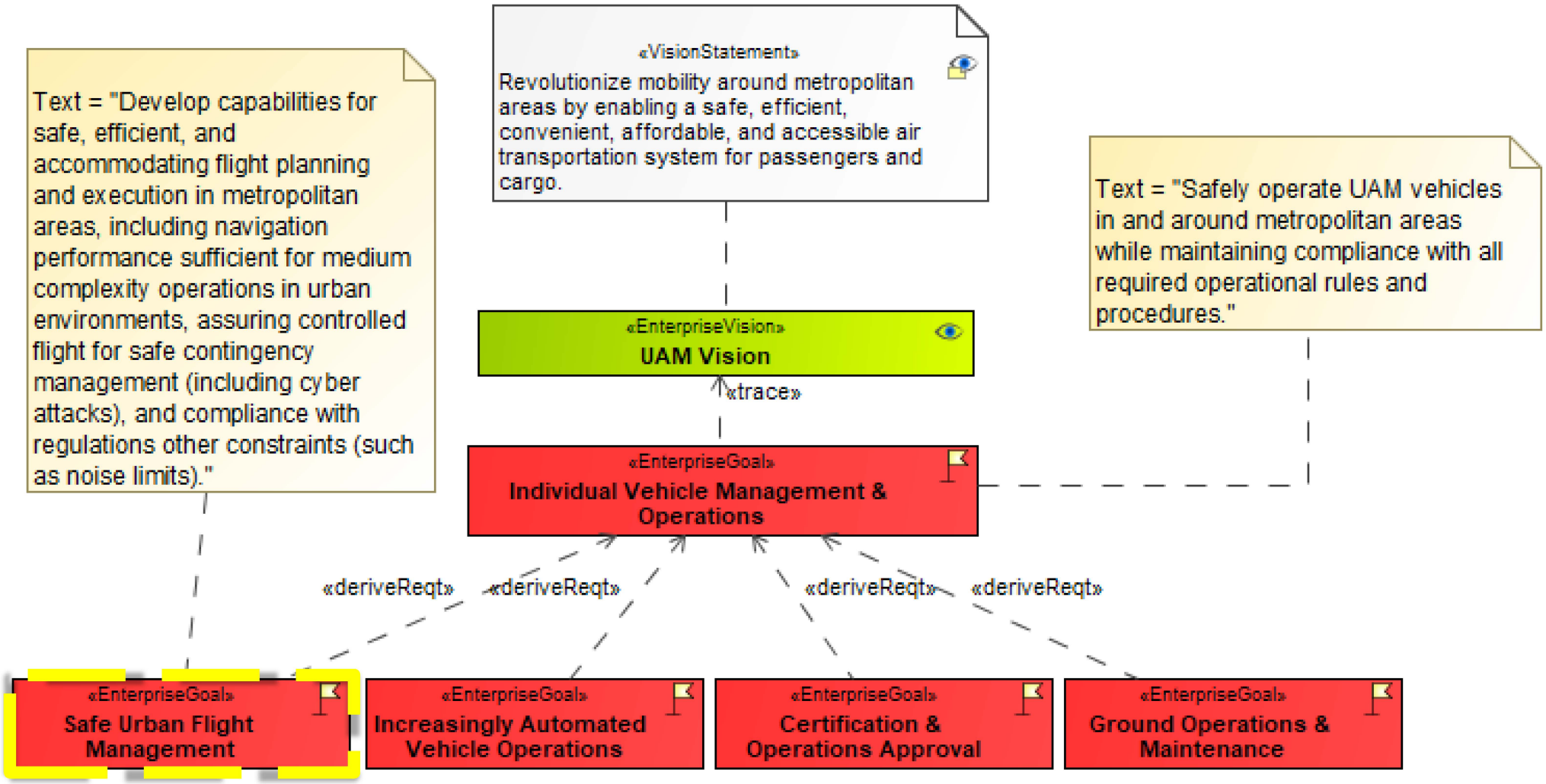
«EnterpriseGoal»
Airspace System Design & Implementation

«EnterpriseGoal»
Individual Vehicle Management & Operations

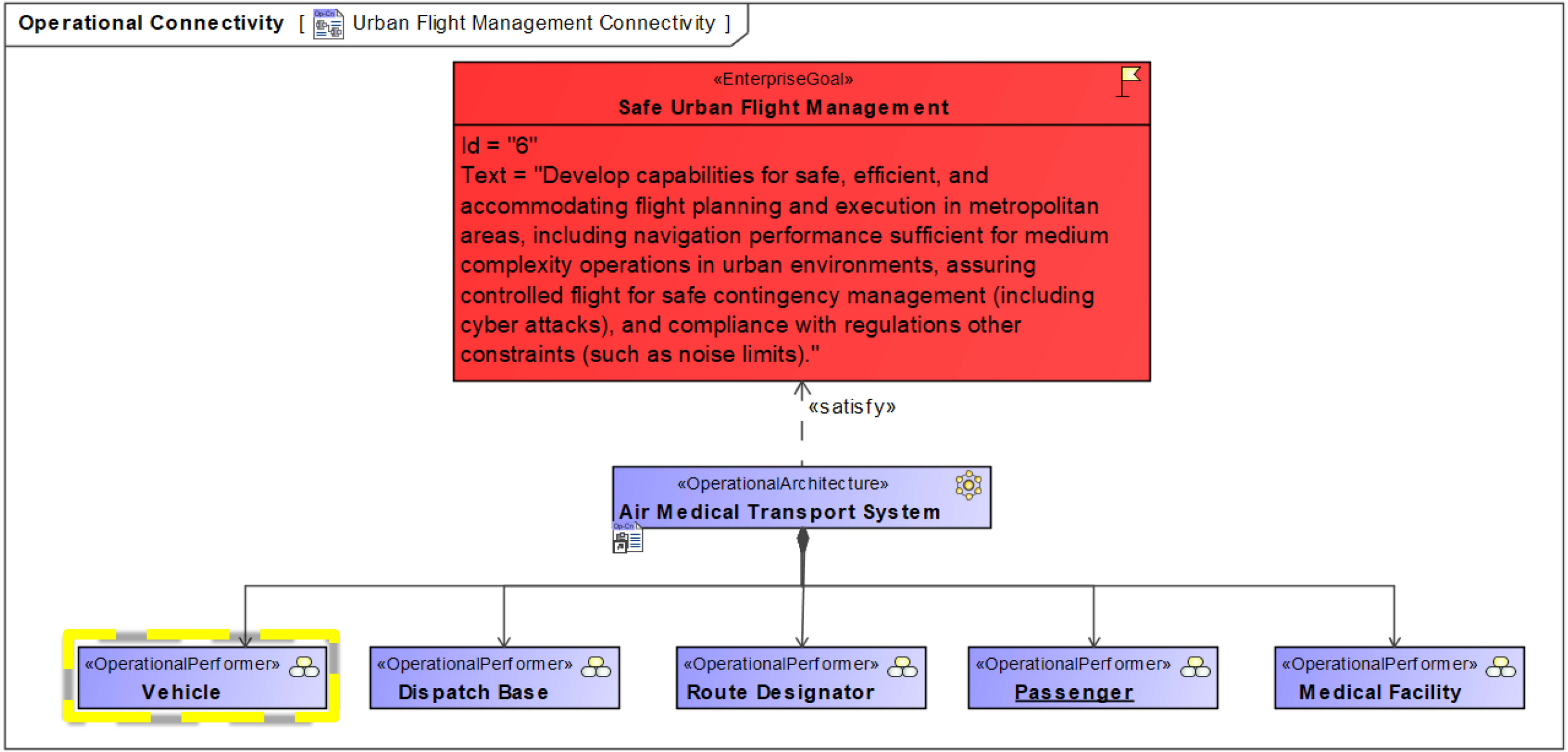
«EnterpriseGoal»
Airspace & Fleet Operations Management

«EnterpriseGoal»
Community Integration

Example MBSE Model: Operational Objectives (Enterprise Goals)



Example MBSE Model: Deriving Operational Architecture from Goals

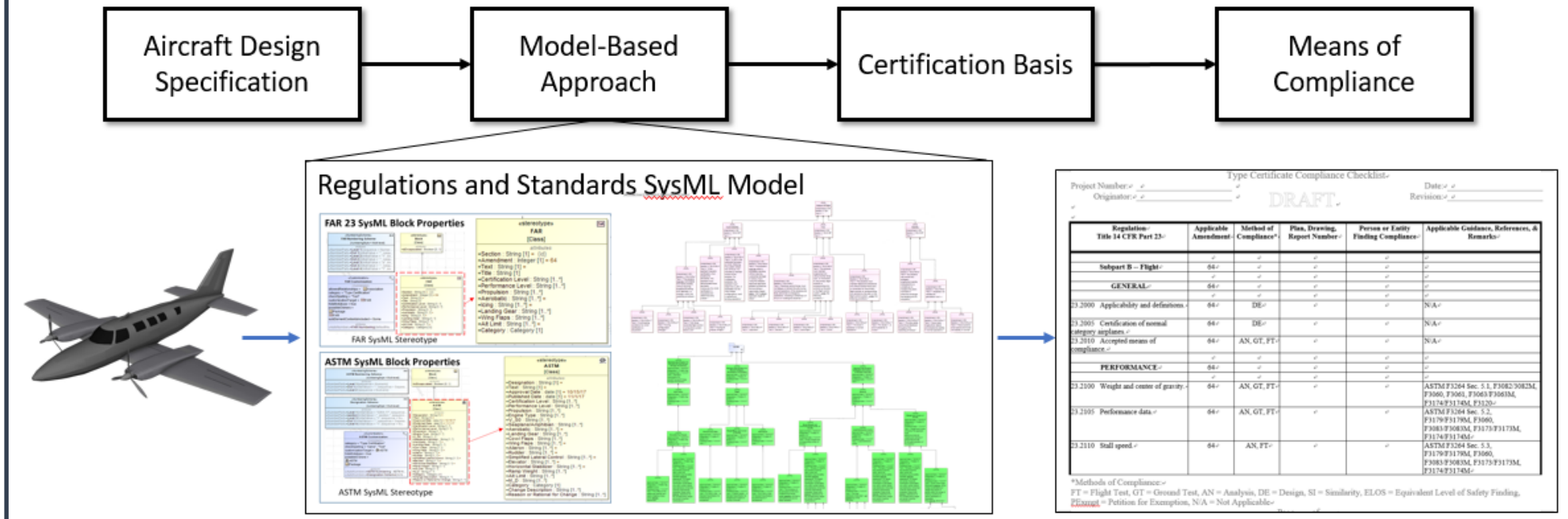


***source:** UAM Passenger Carry OpsCon Section 3.2.1

Another *Example* MBSE Model:

- From Simon Briceno et al. on a task for Nick Borer (Langley):

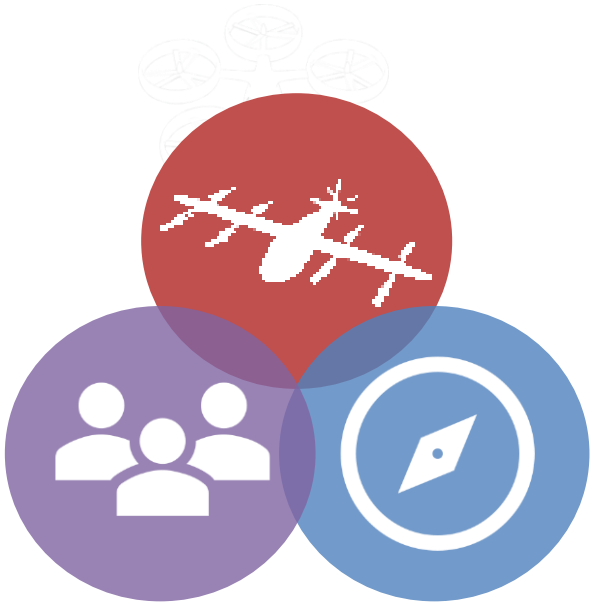
A Model-Based Approach to Manage Type Certification



Georgia Tech Aerospace Systems Design Laboratory

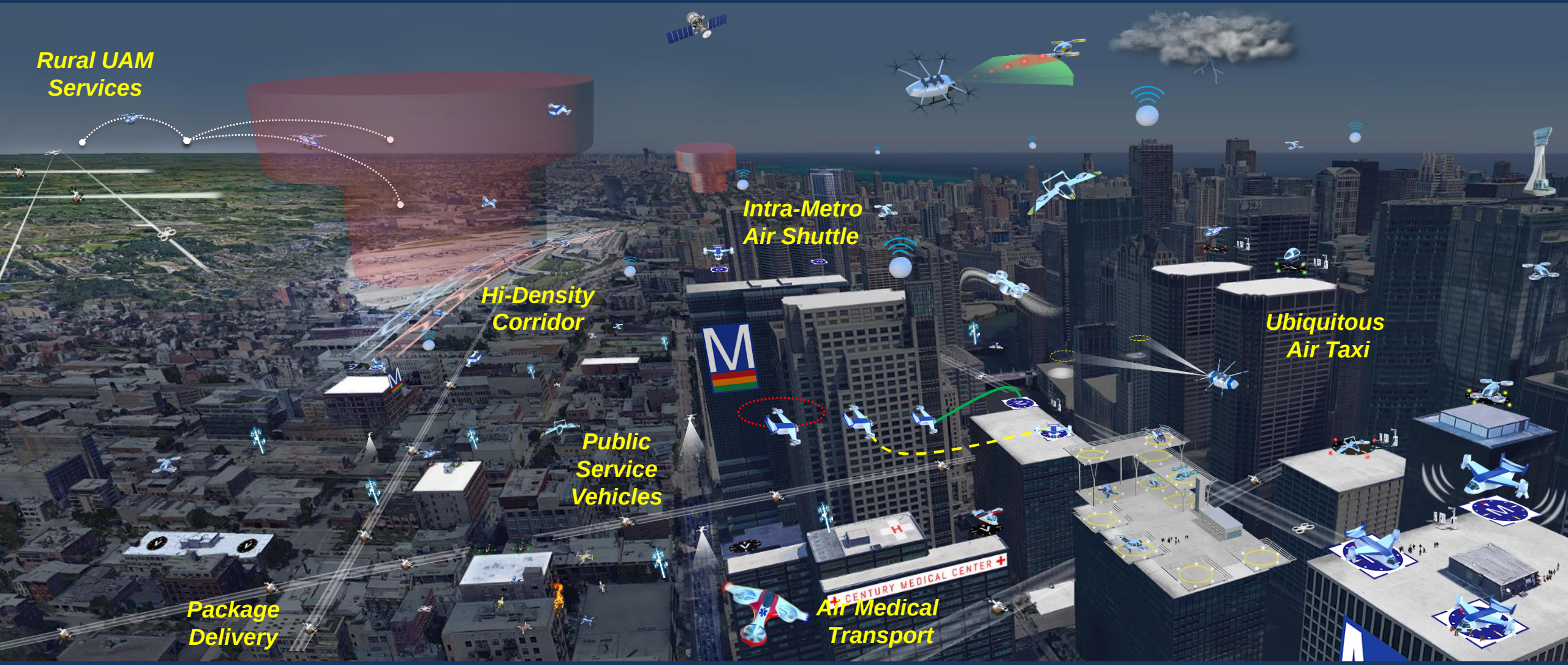
Ecosystem Working Groups

- Background: UAM will require broad collaboration with formal commitments across the ecosystem to be successful
- Scope: Participants will include interested members of the UAM ecosystem with a desire to execute a holistic approach to address end-to-end UAM ecosystem challenges and pathways
- Deliverables: Each working group will deliver products across several critical areas
  - Convene industry to align on a common vision of UAM and mature a consensus UAM ConOps
  - Collectively identify and investigate key hurdles and associated needs, including critical milestones and timelines
  - “Validate” NASA GC Series and NASA UAM Mission Plan
- Execution:
  - March 10-12, 2020: Convene the first workshop as a kick-off for working groups
  - Regular working group meetings led by UMO and supported by NARI
  - Sept/October 2020: UAM Convention



ARMD UAM Goal

Develop a validated UAM System Architecture that defines a safe and certifiable scaled UAM system



Final GC: Scaled urban demonstrations designed to validate the UAM system concept and corresponding set of requirements

BACKUP

Existing Public References from Select NASA-Sponsored UAM-Related Studies

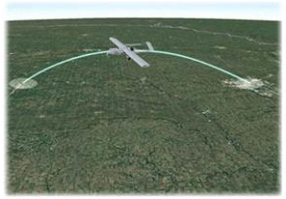
- ODM Roadmapping Workshops Repository:
  - http://www.nianet.org/ODM/roadmap.htm
- Cargo Delivery with Electric VTOL Aircraft (Virginia Tech and Georgia Tech)
  - https://arc.aiaa.org/doi/abs/10.2514/6.2018-2006
- Electrical Infrastructure Study for UAM Aircraft
  - https://www.bv.com/sites/default/files/eVTOL-Electric-Infrastructure-Study.pdf
- Evaluation of Concepts of Operations for sUAS Package Delivery
  - http://arc.aiaa.org/doi/abs/10.2514/6.2016-4371
- Exploration of Potential MVP Missions for Passenger-Carrying UAM
  - https://arc.aiaa.org/doi/abs/10.2514/6.2019-2872
- Impact of Autonomous Ground Vehicles on UAM
  - https://arc.aiaa.org/doi/abs/10.2514/6.2017-3280
  - https://arc.aiaa.org/doi/abs/10.2514/6.2018-2882
  - https://arc.aiaa.org/doi/abs/10.2514/6.2019-2871
- Investigation of STOL Applicability for Urban and Suburban Air Mobility
  - https://arc.aiaa.org/doi/abs/10.2514/6.2018-3054
  - https://arc.aiaa.org/doi/abs/10.2514/6.2018-3055
  - https://arc.aiaa.org/doi/abs/10.2514/6.2019-3121
- Minimum Viable Mission
  - https://arc.aiaa.org/doi/abs/10.2514/6.2019-2874
- ODM Commuter Demand Studies:
  - https://arc.aiaa.org/doi/abs/10.2514/6.2017-3082
- Operational Aspects of On-Demand Mobility (some work ongoing)
  - https://dspace.mit.edu/handle/1721.1/106937
  - https://arc.aiaa.org/doi/abs/10.2514/6.2017-3083
  - https://arc.aiaa.org/doi/abs/10.2514/6.2017-3084
  - https://arc.aiaa.org/doi/abs/10.2514/6.2018-3849
  - https://arc.aiaa.org/doi/abs/10.2514/6.2019-0526
  - https://arc.aiaa.org/doi/abs/10.2514/6.2019-3125
- Passenger Experience Exploration
  - https://ntrs.nasa.gov/search.jsp?print=yes&R=20190028296
- Paths to Autonomous Vehicle Ops for UAM
  - https://arc.aiaa.org/doi/abs/10.2514/6.2019-3255
- Regional Mobility Study
  - https://arc.aiaa.org/doi/abs/10.2514/6.2018-3056
  - https://arc.aiaa.org/doi/abs/10.2514/6.2019-3518
- UAM Market Studies
  - BAH (written report, detailed presentation, overview presentation):
    - https://ntrs.nasa.gov/search.jsp?print=yes&R=20190001472
    - https://ntrs.nasa.gov/search.jsp?print=yes&R=20190000519
    - https://ntrs.nasa.gov/search.jsp?print=yes&R=20190000517
  - Crown Consulting (overview presentation, detailed presentation):
    - https://ntrs.nasa.gov/search.jsp?print=yes&R=20190002046
    - https://ntrs.nasa.gov/search.jsp?print=yes&R=20190026762
- UAM Requirements Sensitivity Analysis
  - https://arc.aiaa.org/doi/abs/10.2514/6.2019-0527

Unlocking UML-4 Helps Enable‡ Other UAM Missions

"Rural" Missions

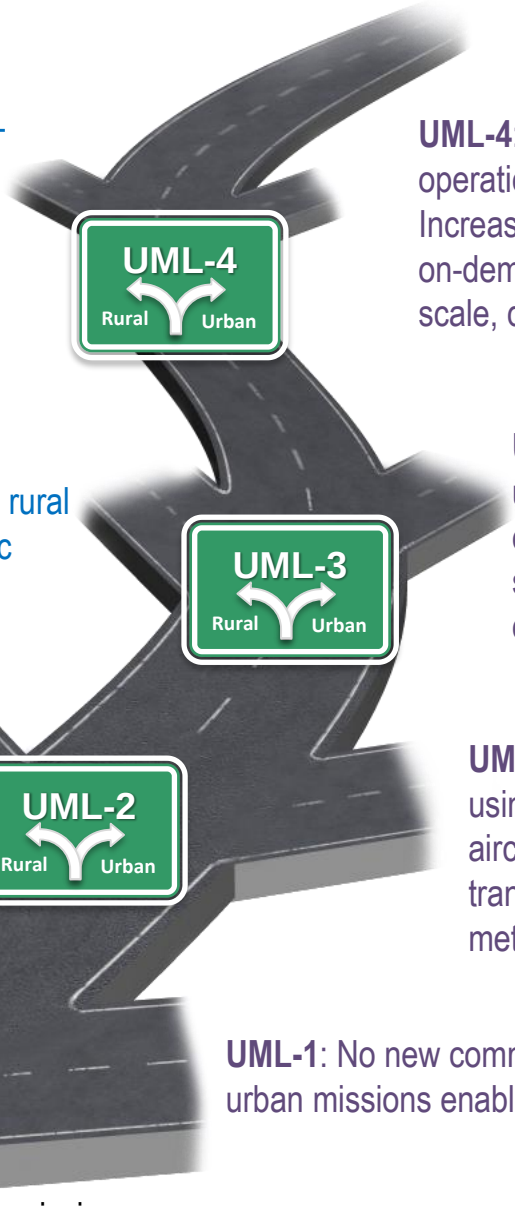
UML-4: Wide-scale on-demand, regional air transportation network

UML-3: Limited inter-city eCTOL networks. Limited "feeder networks" between rural areas to nearest city. Public service missions



UML-2: Cargo delivery to/from warehouses & distribution centers in non-urban areas. Increased utility & safety of General Aviation.

UML-1: No new commercial rural missions enabled.



Urban Missions

UML-4: Increasing network of eVTOL operations to smaller vertiports in IMC. Increase in previous missions (e.g., early on-demand urban air taxi network, wide-scale, distributed small package delivery)

UML-3: Initial eVTOL fleet operations from urban vertiports (e.g., airport transfer, cargo delivery, initial urban air metro); Public service missions (e.g., air ambulance, disaster relief)

UML-2: Initial, commercial UAM flights using eVTOL, eSTOL, and eCTOL aircraft (e.g., ex-urban airport transfers, medical transport, , cross-metro transfers)

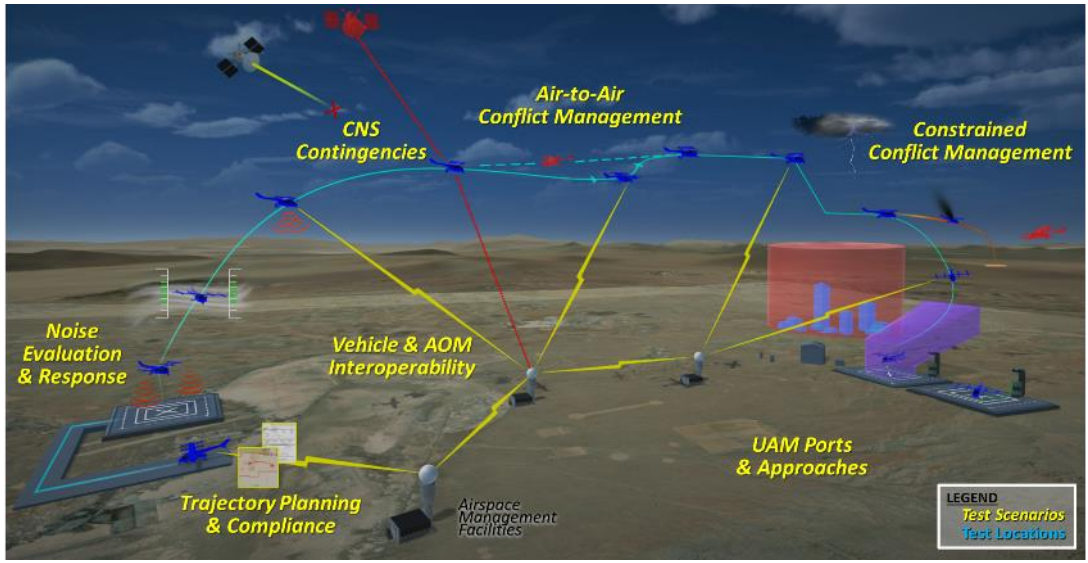
UML-1: No new commercial urban missions enabled.

‡Enable refers to critical technologies that can be engineered to extend to other missions

Summary

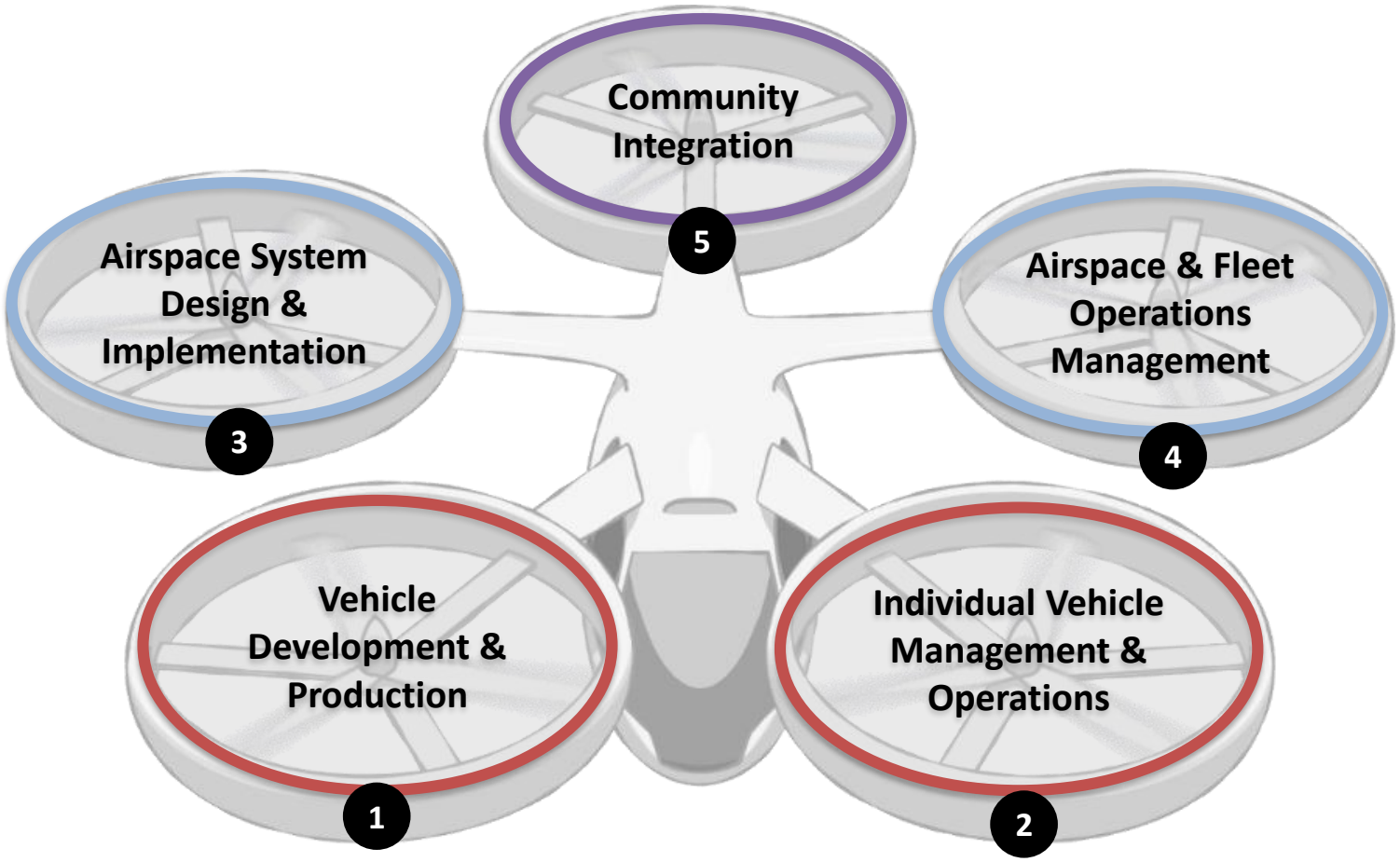
- Overall NASA UAM strategy focus: to develop a consensus “system concept” and “book of requirements & guidelines” in conjunction with the broad UAM community
  - Help to bring together all stakeholders, including industry, academia, the FAA, other government agencies, and local communities
  - Includes development of industry consensus standards, recommended practices, etc.

- The UAM Mission Office (UMO) will help coordinate ARMD efforts in UAM



UAM Vision and Framework

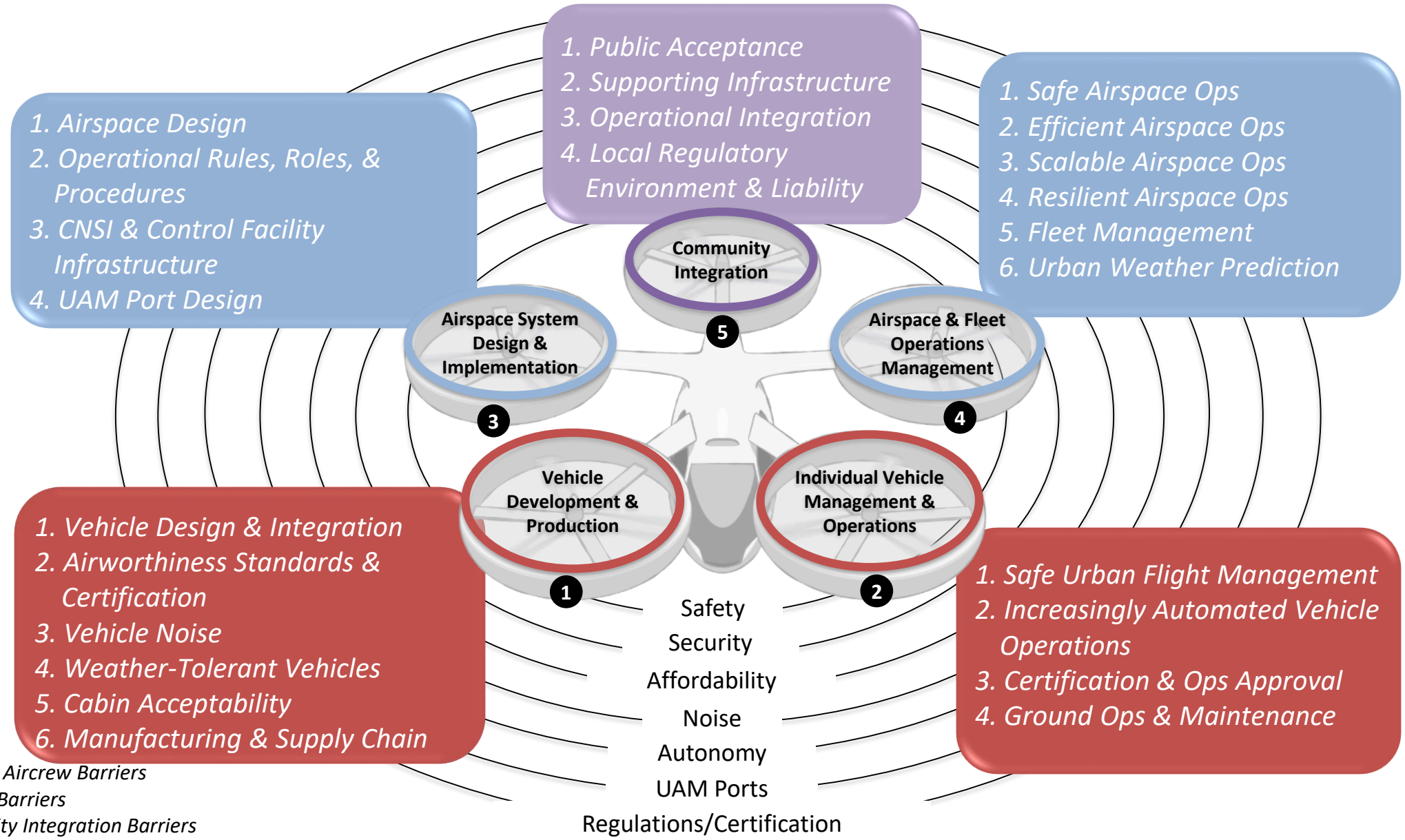
- *Vehicle and Aircrew*
- *Airspace*
- *Community Integration*



Urban Air Mobility (UAM) Vision

Revolutionize mobility around metropolitan areas by enabling a safe, efficient, convenient, affordable, and accessible air transportation system for passengers and cargo

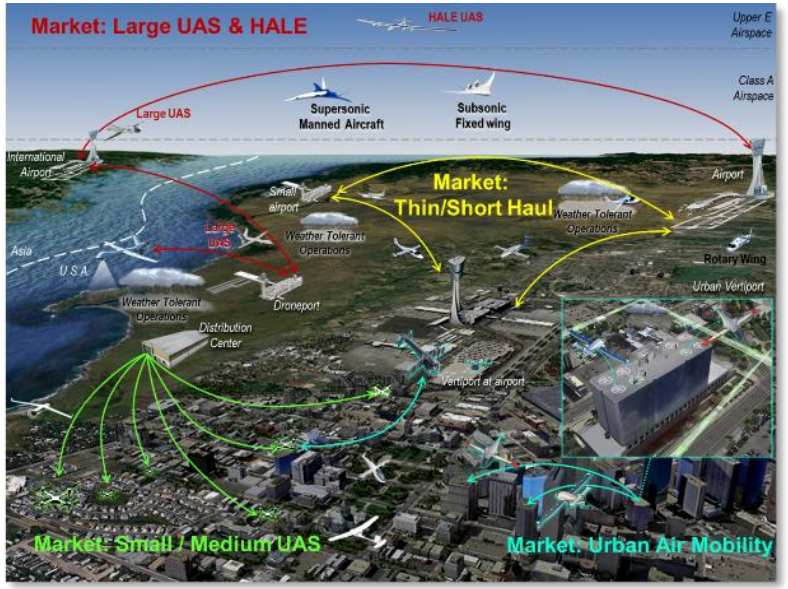
UAM Framework and Barriers

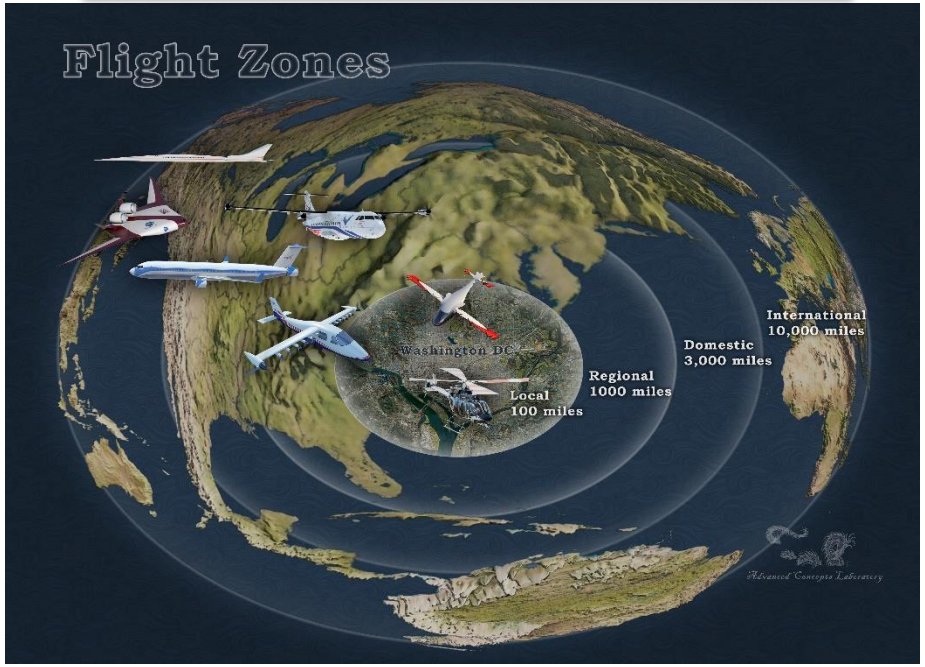


Vehicle & Aircrew Barriers
Airspace Barriers
Community Integration Barriers
 # Pillar number

Terminology: UAM vs AAM vs Other

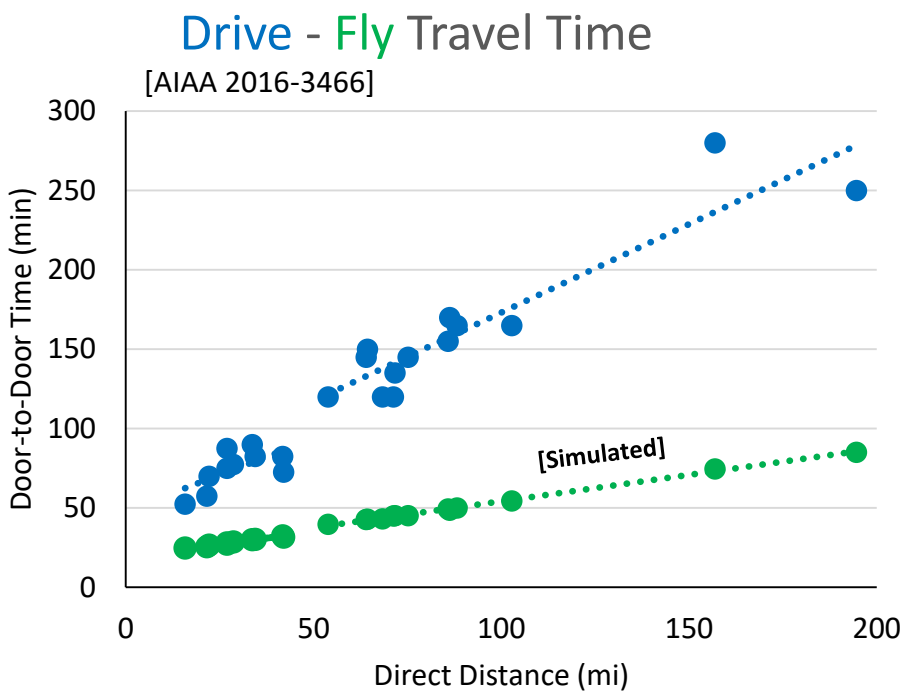
- Urban Air Mobility has a focus on metropolitan areas (which have an urban area at their core)
- "Advanced Air Mobility" to be more broad than just "urban," but how broad is it?
  - All "emerging" aviation markets (EAM)?
    - Just "electric and autonomous" mobility (a different EAM) or also supersonics/hypersonics?
- Another Potential Option:
  - Distance
    - Local Air Mobility (up to ~100 miles)
    - Subregional Air Mobility (end of local up to ~300 miles)
    - Regional Air Mobility (end of subregional up to ~1,000 miles)
    - Transcontinental Air Mobility (end of regional up to ~3,000 miles)
    - Intercontinental Air Mobility (end of transcontinental up to ∞)
  - Operational type
    - Scheduled
    - On-Demand

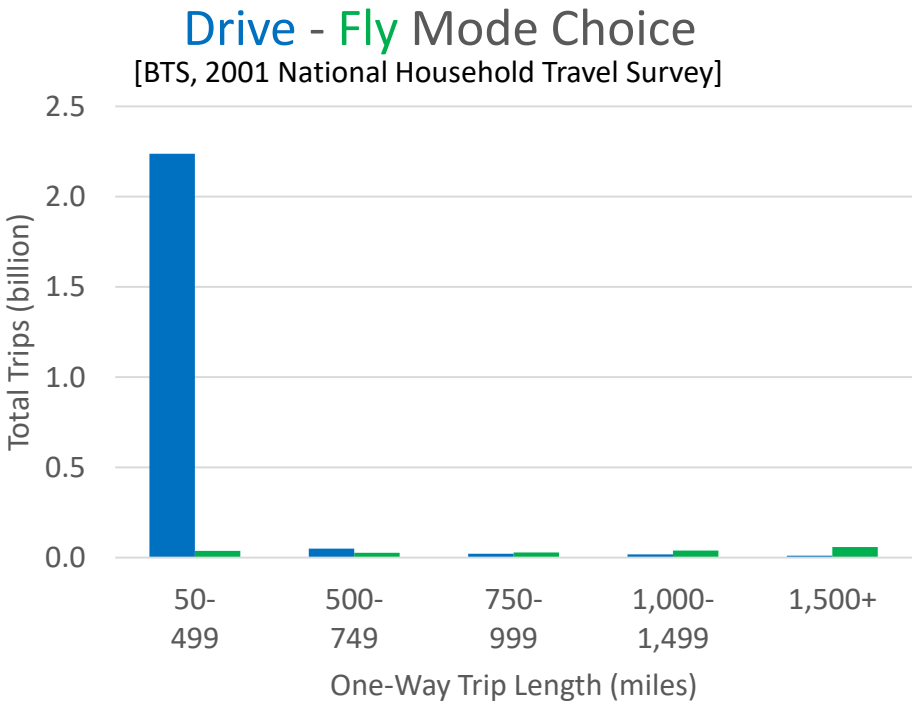




What is On-Demand Mobility (ODM)?

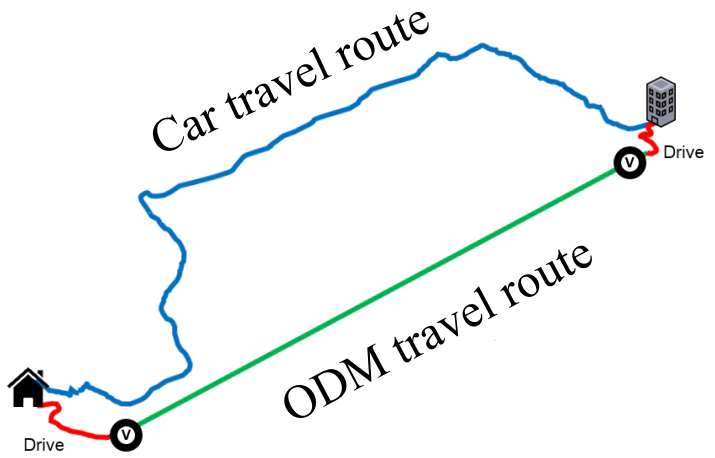
- Immediate and flexible air transportation
  - Users dictate trip origin, destination, and timing
  - 1-9 passengers or up to 2000 lb payload
- ~2-3x faster than cars & hub-and-spoke over ~10-500 mile range





What is On-Demand Mobility (ODM)?

- A range of missions, aircraft types, & operations
  - Enable trips that were not time/cost effective with current transport (e.g., conventional takeoff and landing commuter)
  - Alternative to car travel to avoid/alleviate city congestion (e.g., urban air mobility)
  - New, more rapid methods of cargo distribution (e.g., sUAS package delivery)
- May be enabled by the convergence of technologies including electric propulsion, increasing autonomy, and advanced NAS operations



Prioritized Barriers to Successful ODM System Implementation

Ease of Certification	Affordability	Safety	Ease of Use	Door-to-Door Trip Speed
Average Trip Delay	Community Noise	Ride Quality	Efficiency	Lifecycle Emissions

Prioritized order, but any barrier can limit feasibility, utility, growth

Metrics to Assess Progress Toward Overcoming ODM Barriers

Ease of Certification Time/Cost Required	**Affordability** Total Operating Cost/Pax Mile	**Safety** Fatal Accidents per Vehicle Mile	**Ease of Use** Required Operator Training Time & Cost	**Door-to-Door Trip Speed** Equivalent Speed
Average Trip Delay Time	**Community Noise** Perceived Annoyance	**Ride Quality** Passenger Comfort Index	**Efficiency** Energy/Pax Mile	**Lifecycle Emissions** Total Emissions /Pax Mile

Barriers & metrics involve far more than direct, vehicle parameters.

ODM Reference Missions - highest relevance to workshop participants

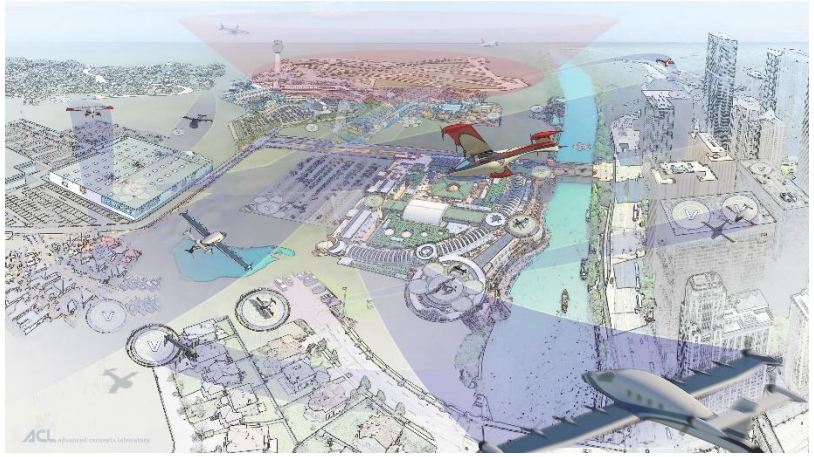
Representative missions provide near- and longer-term opportunities for new technologies, vehicles, operations, & transformational capabilities

CTOL Commuter reference mission

- 9 pax, ~400 mi, 225+ mph, single-pilot
- Moderate industry interest
- Tech scale up/down missions:
    - 1-4 PAX CTOL air-taxi / advanced GA
    - 40 PAX regional airliner

VTOL Air-Taxi reference mission

- 4 pax, ~125 mi, 150+ mph, single-pilot/pilotless
- Strong industry interest
- Tech scale up/down missions:
    - Small public-use UAS (e.g. first responder)
    - 9 pax, VTOL commuter



ODM System Engineering Framework

Barriers/metrics and reference missions provide a basis for systems engineering framework to

a) guide evaluation of various ODM system concepts and

b) assess potential impacts of alternative technologies

c) manage technology R&D

Systems Engineering Framework

Potential Research

Barriers and Metrics

Ease of Certification Time/Cost Required	**Affordability** Total Operating Cost/Pax Mile	**Safety** Fatal Accidents per Vehicle Mile	**Ease of Use** Required Operator Training Time & Cost	**Door-to-Door Trip Speed** Equivalent Speed
Average Trip Delay Time	**Community Noise** Perceived Annoyance	**Ride Quality** Passenger Comfort Index	**Efficiency** Energy/Pax Mile	**Lifecycle Emissions** Total Emissions /Pax Mile

Reference Missions

CTOL Commuter

VTOL Air-Taxi

High-Impact Research

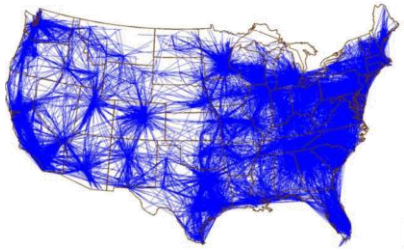
Lower-Impact

ODM Timeline

- Mid- to Late-2000s:
  Personal Air Vehicle Sector

- 2011: Green Flight
  Challenge

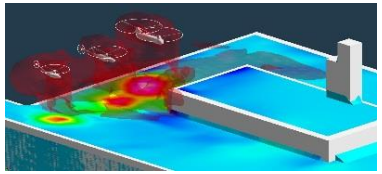
- 2012: Zip Aviation



- 2013: AIAA Transformational Flight Program Committee formed

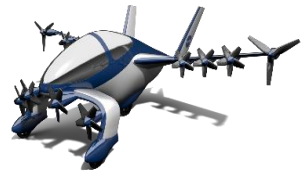
- 2012-2015: GL-10

- 2012-2014: Metropolitan Aerial Transportation
  System Study



- 2014-present: Transformative Vertical Flight Workshops
  SCEPTOR/X-57

- 2015-2016: NASA-FAA ODM Roadmapping Workshops
  Silicon Valley VTOL ODM Case Study



MBSE Overview

- Model Based Systems Engineering (MBSE) is the “utilization of dynamic models to complete standard systems engineering tasks in order to visually represent system functionality and hierarchy”

- MBSE can be used for:
  - Reusability of system elements
  - Improved Communication
  - Centralized information database
  - Increased ability to manage system complexity
  - Scalable to the Problem

- The AAM Project was selected to be a pilot program for MBSE

- MTSI selected MagicDraw to develop the initial MBSE Architecture

MagicDraw

Quick History

- UAM work growing out of multiple, parallel paths within ARMD
- Timeline:
  - 1994-2005: AGATE & SATS Programs
  - 2003-2006: Personal Air Vehicle Sector of the Vehicle Systems Program
  - 2009: Puffin Electric VTOL Concept
  - 2011: Green Flight Challenge
  - 2011-Present: UAS Integration into the NAS Project
  - 2012: Zip Aviation Study
  - 2013: Greased Lightning (GL-10)
  - 2015-2016: ODM Roadmapping Workshops
  - 2015-Present: UAS Traffic Management (UTM) Project
  - 2016-present: X-57
  - 2016: Silicon Valley Study
  - 2017-2018: UAM Market Studies
- Large growth in industry interest/investment over the past ~3 years